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News Briefs

General Developments

Inquiries about News Briefs, where no contact person is identified, should be referred to the Managing Editor, Journal of Research, National Institute of Standards and Technology, Building 820, Room 126, Gaithersburg, MD 20899-0001; telephone: 301/975-3572.

NEW IMAGING TECHNIQUE STRONG ON POWER, GENTLE ON SAMPLES

Please note that an incorrect version of this News Brief was inadvertently published in the Journal of Research, Volume 102, Number 5 issue. The following is the correct version:

There's a new type of kinder, gentler microscopy. Near-field scanning optical microscopy (NSOM) is an emerging technique that combines the non-destructive advantages of optical microscopy with nanometer-scale resolution near that of atomic force or electron microscopes.

NSOM works by channeling laser light through a fiber-optic probe, scanning it about 10 nanometers above a sample surface, and then collecting it on the other side. An opening at the tip of the probe is only about 50 nanometers wide, smaller than a wavelength of visible light (which is several hundred nanometers) but large enough for a small portion of the light energy, or photons, to escape.

NIST physicists, working in collaboration with researchers at the University of Virginia and the Naval Research Laboratory, recently created an image of a "photonic crystal," a test material made by embedding an array of tiny glass cylinders in a matrix glass. To the eye, these two clear glasses are indistinguishable. However, they have slightly different indices of refraction (bending light at slightly different angles). Consequently, the NSOM image shows that, rather than traveling straight through the sample, light is "guided" through the crystal by the cylinders.

The NSOM technique has been developed and embraced by numerous laboratories throughout the world in order to image and characterize nanometer-scale features on biological membranes, semiconducting devices and substrates, fiber-optic communications components, and many other materials. A major goal of the NIST program is to further refine NSOM measurements and modeling so that NSOM can provide truly quantitative measurements of the optical properties of these structures. For example, accurate measurements of the size of the glass cylinders and their index of refraction should result from NIST's collaborative research on photonic crystals. In addition, other NIST research groups are working on developing applications for NSOM, including nanometer-scale chemical composition analysis.

The image described above soon will be available in the "Gallery" section of the NIST World Wide Web site, http://www.nist.gov.

For technical information about the NSOM project, contact Lori Goldner, A320 Metrology Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-3792, lori.goldner@nist.gov.

FAILURE OF TINY RIVETS MAY HAVE SUNK "UNSINKABLE" LINER

When the remains of the *RMS Titanic* were discovered more than two miles beneath the surface of the North Atlantic in 1985, the story of the great liner once dubbed "unsinkable" by the press began moving from legend into scientific fact. Numerous research investigations have been piecing together the details of what really occurred on April 14-15, 1912, after *Titanic* struck an iceberg, broke in half and carried more than 1500 people to their deaths. Now, the answer to one of the most elusive questions—Why did the 46000 ton ship sink in less than 3 hours?—may be contained in a new report from NIST.

The culprit, says a NIST scientist in the report, is very possibly one of *Titanic's* smallest components—the 3 million wrought iron rivets used to hold the hull sections together.

The scientist performed metallurgical and mechanical analyses on steel and rivet samples recovered from the *Titanic's* hull. His examinations revealed that the wrought iron in the rivets contained three times today's allowable amount of slag (the glassy residue left behind after the smelting of ore), making it less ductile and more brittle than it should have been. This finding provides strong evidence that *Titanic's* collision with the iceberg caused the rivet heads to break off, popped the fasteners from their holes and allowed water to rush in between the separated hull plates.

Photographs of *Titanic's* sister ship, the *RMS Olympic*, back up the rivet failure theory. Taken after the *Olympic* collided with another vessel in 1911, the photos clearly show dozens of vacant holes in the hull where rivets once sat. Sonar and other evidence gathered during a 1996 visit to the Titanic also point to seam and rivet failure.

For a single copy of *Metallurgy of the RMS Titanic* (NISTIR 6118), send a request to Public Inquiries by fax at (301) 926-1630 or by email at inquiries@nist.gov.

LARGEST EVER EXPANSION OF MASS SPECTRAL DATABASE AVAILABLE

Analytical chemists now can take advantage of improved accuracy and a 75 % expansion of the NIST/EPA/NIH Mass Spectral Database for personal computers. Scientists use this tool for identifying unknown compounds.

The new version, NIST 98, now includes the largest expansion ever of the NIST mass spectral library, bringing the total number of spectra to nearly 130 000 and the number of compounds to more than 107 000. In addition to the expansion, NIST 98 reflects improved accuracy resulting from a 10 year, spectrum-by-spectrum review of the entire library by a team of experienced mass spectrometrists.

NIST 98 can run on personal computers with Microsoft Windows 3.1, Windows 3.11, Windows 95 or Windows NT, and requires 120 megabytes available hard disk space. The price is $2090. Owners of a previous version may upgrade for $750.

For more information, or to order the database, contact the Standard Reference Data Program, Rm. 113, Building 820, NIST, Gaithersburg, MD 20899-0001, (301) 975-2208; fax: (301) 926-0416, srdata@nist.gov. Information also is available on the World Wide Web at http://www.nist.gov/srd/.

NIST HELPS SHUTTLE FLY FREE OF FLAWS IN FLOW MEASUREMENT

Researchers at NIST have designed and successfully tested meters for measuring the flow of liquids and gases in the main engines of NASA's space shuttle. Pressure loss increases as the square of the flow velocity, so the pressure loss across a conventional flowmeter can become unacceptably large at high flow velocities. Therefore, the NIST researchers developed flowmeters (called vortex shedding flowmeters) that could assess such flows without the pressure loss problem.

The NIST flowmeters are designed to measure flow under conditions found in selected ducts of the shuttle's main engines where higher than normal velocities are encountered. Flow measurement of the ducts is needed to monitor and control the engines during flight. NIST researchers found the presence of bends in the duct near the flowmeter actually increased its performance, particularly in signal quality. This is in contrast to traditional situations where flowmeters are placed in long, straight sections of duct for maximum efficiency.

One innovative method used during the testing of the new shuttle flowmeter was the simulation by NIST scientists of the flow of liquid oxygen with a municipal hydroelectric plant's water flow system.

A paper describing the flowmeter research, no. 2-98, is available from Sarabeth Harris, MC 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, sarabeth@boulder.nist.gov.

POSIX TESTING PROGRAM A SUCCESS

On Jan. 1, 1998, NIST ended its successful FIPS 151-2 Portable Operating System Interface (POSIX) Conformance Testing Program. A final list of accredited testing laboratories and validated products for Federal Information Processing Standard (FIPS) 151-2 POSIX, has been posted on the Web at http://www.nist.gov/ctdirectory.html.

The NIST POSIX Testing Program was established on May 1, 1991, for FIPS 151-1. It was superseded on Oct. 15, 1993, by the FIPS 151-2 program. The program was administered by NIST and consisted of five National Voluntary Laboratory Accreditation Program (NVLAP) accredited testing laboratories. The NIST-PCTS (POSIX conformance test suite), prepared by NIST, tested system implementations for conformance to FIPS 151-2. A FIPS 151-2 Certificate of Validation was issued for products that met program criteria when tested in laboratories accredited by NVLAP.

Testing for FIPS 151-2 continues in the private sector. Both the Institute of Electrical and Electronics Engineers, Inc. Standards Division and the Open Group

have announced validation services for FIPS 151-2. NIST is assisting both organizations in establishing their testing services.

In summary, the NIST POSIX Testing Program issued FIPS 151-2 Certificates of Validation for 205 products from 21 product suppliers. These products were tested on systems from 27 suppliers. Therefore, a total of almost 350 products successfully tested for FIPS 151.

TIME SYNCHRONIZATION FOR DISTRIBUTED COMPUTING

Synchronized clocks are important in the distributed computing market, where they support commerce, security, monitoring, and billing. NIST provides a synchronization service on the Internet with 10 ms precision; the service receives about 2 million synchronization requests per day. NIST would like to increase the precision of the service to 1 μs by overcoming the problem of variability of delays.

To achieve this precision, NIST is developing a hardware supplement employing the MultiKron(r) clocking chip and low-cost commercial global positioning system (GPS) receivers. The hardware instrumentation is currently in the testing phase of development. Although such hardware support is sufficient to achieve higher precision time synchronization, the cost and availability of such specialized hardware limits its use. NIST is investigating distributed software time synchronization algorithms targeted to achieve 1 μs precision and is using the NIST hardware support instrumentation to evaluate the precision achieved and identify the impediments encountered. These low-cost techniques and guidelines then can be transferred to industry.

MOIST 3.0 COMPLETED AND RELEASED

NIST has completed and released an enhanced version of MOIST, a personal computer program that predicts the transfer of heat and moisture in walls, flat roofs, and cathedral ceilings. MOIST 3.0 represents a significant advancement over the previous DOS-based version. MOIST 3.0 utilizes an easy to use graphical user interface that allows the user to construct virtual building assemblies and quickly assess the resulting thermal and moisture performance.

The program contains an extensive heat and moisture property database for building materials and hourly weather data for 51 cities within the United States and Canada. Unlike the previous version, MOIST 3.0 incorporates algorithms that predict the indoor relative humidity of the building being analyzed rather than assuming a fixed relative humidity. This capability is useful in determining if ventilation strategies provide a means of achieving acceptable moisture performance.

The program is used by building practitioners to (1) determine if vapor retarders are needed in cold climates, and if so where they should be placed; (2) predict surface relative humidity at the construction layers in hot and humid climates, thereby determining the potential for mold and mildew growth; (3) determine the drying rates for materials containing original construction moisture; and (4) investigate the moisture performance of cold refrigeration storage rooms. Moisture analysis makes it possible to design building constructions that perform with considerably less moisture-induced material degradation.

It is estimated that increased energy usage due to moisture is approximately $150 million per year. If through the use of MOIST, moisture accumulation in 20 % of the affected roofs and walls was elimi-nated, an annual savings of $30 million per year would result. Proper moisture analysis and construction would also decrease the enormous expenditure of funds required to replace moisture damaged building materials and coatings as well as reduce the litigation associated with moisture-related damage.

The previous DOS-based MOIST is being used by over 1200 building practitioners. It is anticipated that the new release will be in greater demand due to its ease of use and enhanced analysis capabilities. The new MOIST 3.0 software can be obtained by contacting Paula Svincek at (301) 975-5648 or via email at MOIST@nist.gov.

TWO ACCREDITATION BODIES RECOGNIZED

As part of the NIST Accreditation Body Evaluation Program (ABEP) under the Fastener Quality Act (FQA), the following two additional accreditation bodies were recognized Dec. 19, 1997: the Japan Accreditation Board of Conformity Assessment, and the Standards Council of Canada.

As recognized ABEP bodies, they may accredit fastener testing laboratories that meet FQA requirements. At the present time, approximately 65 laboratories are undergoing evaluation by these two bodies in Japan and Canada. There are now six recognized bodies for accrediting fastener testing laboratories, including the NIST NVLAP program. A total of approximately 500 laboratories are at various stages of the accreditation process conducted by these six recognized accreditors. Most of these laboratories are likely to be accredited by May 26, 1998, the implementation date of the act.

NEW APPROACH DEVELOPED IN FABRICATION OF MAGNETIC NANOWIRE ARRAYS

Researchers at NIST have developed a new approach to producing large, uniform arrays of magnetic nanowires to aid magnetic information storage technology. Developing a better understanding of small particle magnetic behavior is a critical challenge faced by the information storage industry. Crucial to that challenge is the fabrication and characterization of magnetic structures with dimensions smaller than the magnetic domain wall thickness. The researchers describe in a forthcoming article the fabrication of wires that are about 30 nm thick, 90 nm wide and 0.3 mm long.

Production of the magnetic nanowires begins with a corrugated surface produced by the laser-focused deposition of chromium atoms. The resulting chromium lines are about 40 nm high and 80 nm wide and are spaced precisely 212.78 nm apart. The subsequent evaporation of iron onto this array of chromium lines at glancing incidence results in the deposition of iron nanowires on one side of the lines while the other side remains in shadow.

The investigators image the nanowire magnetic domain structure with scanning electron microscopy with polarization analysis (SEMPA), revealing uniform magnetization along the length of the wires. These domains span the width of each wire and are about 16 m long.

Future extensions of this work include the possibility of fabricating two-dimensional arrays of nanometer scale iron islands. Such arrays could be used for magnetic recording, with each island recording one datum bit, providing storage densities of about 2.2 Gbit/cm^2.

NIST TO DEVELOP LASER-COOLED CLOCK FOR THE INTERNATIONAL SPACE STATION

NIST scientists, in collaboration with the University of Colorado, have been awarded a NASA flight-definition contract to develop a laser-cooled cesium clock for scientific and technical applications in earth orbit.

Laser-cooled clocks are more accurate than standard atomic beam devices, and operating the clock in the free-fall orbit environment further improves accuracy. The slower atomic travel times and reduced Doppler shifts of laser-cooled clocks improve accuracy and signal-to-noise ratios, resulting in better long-term stability. This stability allows longer averaging times and better sensitivity to very small perturbations. Operating the clock in orbit will increase the observation time of the atomic transition by a factor of 10 or more, since the atoms will not be pulled out of the observation region by gravity. The frequency of the space clock is expected to have a relative uncertainty of less than 10^{-16}, more than a factor of 10 improvement over terrestrial atomic clocks.

There are three distinct objectives for the project (1) to perform fundamental experiments, including gravitational red shift measurements, a possible test of the isotropy of the one-way speed of light, and tests of local position invariance and local Lorentz invariance; (2) to achieve certain technical objectives including improved determination of GPS orbital parameters, an improved realization of the cesium definition of the second, and improved comparisons of earth-bound clocks; and (3) to serve as a demonstration of the space clock performance providing the basis for other significant relativity experiments in other orbits (such as a close solar orbit). These include experiments on Shapiro delay and measurement of nonlinear terms in the gravitational red shift. This project thus has both long-term and near-term relevance to the U.S. space program.

The clock should be ready for flight in 5 to 7 years.

SIMPLE MULTIWAVELENGTH CROSS CORRELATOR USED FOR ULTRASHORT PULSE

NIST researchers recently employed semiconductor photodiode materials to demonstrate greatly simplified devices to accurately measure cross correlations and time delays between ultrashort laser pulses of widely different tunable wavelengths.

Measurements of the temporal profiles of ultrafast laser pulses typically are performed by correlating the temporal profile of one laser pulse with another short pulse in a nonlinear optical material. Commercial instruments can measure autocorrelation times between two ultrafast laser pulses of the same wavelength. However, many experiments require ultrashort pulses at several wavelengths, and no simple methods have been developed to obtain time correlations over wide tuning ranges of multiple colors of light. It is frequently challenging to locate the zero time delay between two different wavelength pulses when the phase matching conditions of the nonlinear crystal are also uncertain.

Recently, highly simplified autocorrelation devices have been constructed using semiconductor photodiode materials as the nonlinear response medium. Unlike nonlinear optical crystals, these materials do not require precise alignment and angles of phase matching, as do nonlinear optical crystals. In addition, the semiconductor diode materials have been demonstrated to be effective down to measurement times of 6 fs or less.

In the NIST devices, zero time delays and accurate cross correlations were measured for 100 fs laser pulses of dramatically different wavelengths, such as 775 nm and 1300 nm. Cross correlations are obtained so long as the sum of the two photon energies exceeds the photodiode bandgap energy. The devices may permit strong, reproducible calibration pulses from one laser to be used to calibrate pulse durations of unknown, weak, and different-wavelength laser pulses, or to measure broadened pulses exiting a fiber. The simplicity of the devices may also allow miniaturization for field measurements.

The ease of obtaining zero time delays for numerous multiple wavelengths has been established, since wide tuning of the colors provides reproducible cross correlation results without alteration of the angles or imaging of the laser pulses onto the diode material. The photodiode autocorrelator also accurately measures the temporal overlap of two ultrafast laser pulses of the same wavelength emanating from a near field optical microscope fiber optic tip over a small diameter at a surface, providing an excellent means of determining the temporal overlap of the pulses at the surface of various samples.

NIST-LED BEAM PROFILE ROUND-ROBIN COMPLETED

NIST recently com-pleted a laser beam characterization round-robin conducted in response to industry requests. This round-robin involved eight U.S. manufacturers of beam-profile meas-urement equipment and was conducted somewhat differently than typical round-robins in which a transfer standard or characterized artifact is sent around to the involved participants to indirectly compare measurement systems and techniques. In this instance, the companies brought their measurement equipment (beam profilometers and wavefront analyzers) to a NIST laboratory where measurements were made on two NIST lasers. One was an intensity-stabilized helium-neon gas laser, which had a near-Gaussian irradiance distribution, and the other was a specially designed, mode-tunable, solid-state laser built by NIST scientists and a guest scientist from Germany. This tunable laser is capable of producing transverse modes ranging from the lowest order fundamental mode to mode order 40. For this round-robin, the first higher order mode was used because radiation along one axis propagates as a typical Gaussian beam whereas the radiation along the orthogonal axis has much greater divergence. This allowed a more rigorous test of the participants' measurement equipment.

For the past 6 years, the ISO (International Organization for Standardization) laser standards committee (ISO/TC 172/SC 9) has been developing standards on various aspects of laser radiation properties and associated measurements. A recently completed standard from this committee prescribes definitions and measurement procedures concerning the principal aspects of laser beam profile and propagation characteristics. At the request of several U.S. beam-profile system manufacturers, NIST conducted a round-robin several years ago that led to the identification of weaknesses in an earlier version of the ISO document and was instrumental in the development of the current standard. This new round-robin, requested by the U.S. Laser and Electro-Optics Manufacturers Association, showed a significant improvement in the ability of the participants to measure the required beam parameters. Except for one outlier (later found to be caused by an overcorrection by a participant for detector background levels), the results by all participants agreed within 2 % to 5 %, which is considered noteworthy for these types of measurements.

ALOFT-FT™ DEVELOPED FOR PERSONAL COMPUTERS

ALOFT-FT™ (A Large Outdoor Fire plume Trajectory model—Flat Terrain) is a computer-based model to predict the downwind distribution of smoke particulate and combustion products from large outdoor fires. Measurements and observations at experimental fires have shown that the downwind distribution of smoke is a complex function of the fire parameters, meteorological conditions, and topographic features. To incorporate these features, NIST has developed a smoke plume trajectory model that solves the fundamental fluid dynamic equations for the smoke plume and its surroundings. ALOFT-FT is the public domain version of the model for flat terrain using windows-based personal computers. The program contains a graphical user interface for input and output and a user modifiable database of fuel and smoke emission parameters. The output can be displayed as downwind, crosswind, and vertical smoke concentration contours. Information on using the program is available with on-line help commands in the program. ALOFT-FT was developed to aid in the planning process for the intentional burning of crude oil spills on water. The program also may be useful in predicting the smoke plume trajectory from other large outdoor fires.

NIST STAFF CLARIFY MECHANISM OF SUPER FLAME SUPPRESSANT

With the cessation of production of the halon fire suppressants, there is a search for equally effective alternatives. One approach being pursued by NIST scientists is to understand the mechanisms of highly efficient chemicals, even if they are not usable for other reasons. They would then look for other chemicals that possess the desirable features without the undesirable attributes. Iron pentacarbonyl is one of those chemicals. Its inhibition efficiency is very high up to a point, but then falls off sharply. It is also highly toxic. NIST scientists, along with a guest worker from Russia and a visiting scientist from Germany have examined this compound added to pre-mixed and diffusion methane/oxygen/nitrogen flames. They have constructed a gas-phase inhibition mechanism involving catalytic removal of hydrogen atoms by iron-containing species. For the premixed flames, the model results are compared with changes in burning velocity; for the diffusion flames, the comparison is with the flame strain rate at extinction. At low additive levels, the predictions and experimental data compare well, indicating that the flame is mainly slowed by homogeneous, gas-phase chemistry. However, the model does not sufficiently account for the falloff. The team suggests this drop in efficiency is due to condensation of the active species Fe and FeO, which are calculated to be supersaturated in some regions of the flame. The results are to appear in Combustion and flame.

TECHNIQUE DEVELOPED TO MEASURE EFFECTS OF TRIBOCHEMISTRY ON FILM STRENGTH

Recent trends to miniaturize devices such as magnetic hard disk drives, microelectromechanical devices, and sensor arrays have created a need to examine the feasibility of a permanent lubrication by a monolayer of organic molecules. In such devices, the spacing between surfaces and the size of the system allows only one or two monolayers to control adhesion, stiction, friction, and wear.

One complicating issue is the effect of tribochemistry (chemistry that occurs under rubbing conditions), whereby the molecular layer deposited on a surface undergoes chemical changes under sliding conditions. In the case of a monolayer, measurement of the changes and the resultant effects on system performancebecomes a challenge.

NIST scientists have developed a new technique to measure the effects of tribochemistry on film strength. First, submicrometer diamond particles are deposited on a surface covered with a thin layer of organic adhesive. Using this surface, multipoint nanometer-deep, single-pass scratches are made on the monolayer-covered surface. Monolayer film strength is measured and chemical changes are determined by grazing angle Fourier infrared and soft x-ray absorption spectroscopy as a function of number of passes.

The development of such a technique will lead to future examination of molecule-surface interactions from surface bond disruptions. Material issues such as the potential reactivity of various surface polishing layers, oxide layers, and thin films can be examined.

HOMOGENEOUS MATERIALS PREPARED BY RAPID SOLIDIFICATION FOR STANDARD REFERENCE MATERIAL APPLICATIONS

A major use of Standard Reference Materials is to provide materials of known uniform composition. Industry applies these samples to calibrate and standardize the measurement systems that monitor industrial products going into and coming from production lines. To provide samples for this purpose even more homogeneous than those now available, NIST has produced white cast iron samples by rapid solidification techniques.

White cast iron is formed when molten iron solidifies too rapidly to allow formation of the separate graphite phase which imparts a grey color to more slowly solidified cast irons. However, normal casting processes still allow compositional inhomogeneities on a millimeter scale to develop in white cast iron. To produce a more homogeneous material, inert gas atomization was applied, in which high velocity argon gas impacted a stream of molten cast iron and broke up the stream into small droplets, averaging about 50 μm in diameter. As a result of their small size, these droplets cooled and froze very rapidly into powder particles, and any segregation of constituents within the particles occurred on an extremely fine (micrometer) size scale.

These powders then were consolidated into fully dense bulk samples by hot isostatic pressing, which maintained homogeneity on this fine scale throughout the entire sample. These rapidly solidified samples are being evaluated for suitability as Standard Reference Materials by the NIST Standard Reference Materials Program in round robin tests with industrial users.

Volume 103, Number 2, March–April 1998
Journal of Research of the National Institute of Standards and Technology

INTERNATIONAL COMPARISON OF CHARPY IMPACT REFERENCE MACHINES AND SPECIMENS

A comparison of the Charpy impact reference machines and specimens used to support international standards (ISO, JIS, ASTM, and EN) for material toughness evaluation has been organized by NIST. Reference specimens for verifying the performance of Charpy impact machines are produced by the Laboratoire National d'Essais in France, the Institute for Reference Materials and Measurements in Belgium, the National Research Laboratory of Metrology in Japan, and NIST in the United States. Each laboratory will contribute 300 reference specimens for the comparison testing. These specimens will be tested by each laboratory using their reference machines. The data from the comparison will be used primarily to determine the bias among the reference machines and provide a horizontal link among the verification programs. The data also will be used to evaluate specimen-machine interactions, and the effects of striker geometry on the impact energy and lateral expansion of the specimens. The latter issue is important because ASTM specifies a striker with a 8 mm radius and ISO specifies a striker with a 2 mm radius. The results of the comparison will be published in the ASTM Symposium on Procedures and Specimens for Verification of Pendulum Impact Machines (May 1999).

NIST TBT AGREEMENT ACTIVITIES REPORT PUBLISHED

This report on TBT Agreement Activities of the National Institute of Standards and Technology 1996 (NISTIR 6105) describes the role of NIST's National Center for Standards and Certification Information (NCSCI) in support of the World Trade Organization (WTO) Agreement on Technical Barriers to Trade (TBT Agreement). NCSCI staff operate the U.S. WTO TBT inquiry point for information on standards, technical regulations, and conform-ity assessment procedures that might affect U.S. trade. Center staff also coordinate U.S. comments on proposed foreign regulations, arrange for translations of foreign technical regulations and standards, and maintain the WTO hotline—(301) 975-4041—that provides the latest information on proposed foreign government technical regulations issued by the WTO Secretariat in Geneva. In 1996, NCSCI staff responded to 306 requests for TBT-related information, received 460 notifications of proposed technical regulations, and participated in numerous activities to strengthen implementation of the TBT Agreement. Copies of the annual report are available from NCSCI, Building 820, Room 164, ext. 4040, or will become available on the Internet at http://ts.nist.gov/oss.

ENERGY-RELATED INVENTIONS PROGRAM MAKES RECOMMENDATIONS

NIST recently prepared technical evaluation reports on five commercially promising innovative technologies in response to its current statutory mandate under the Energy-Related Inventions Program.

Fiber-Optic Current Transformer—a signal-sensing device with a two-part transduction mechanism to measure current in high-voltage power lines. The system operates by means of a Rogowski coil surrounding an electric cable.

Low-Cost, Lightweight, High-Performance Electric Vehicle—a lightweight electric vehicle (LEV) designed to seat two passengers in tandem. The LEV weighs about 360 kg and has a payload capacity of about 180 kg.

Membrane Technology to Remove Entrapped Air—an invention that proposes to use membrane technology to separate and remove air and other noncondensable gases from ammonia refrigeration systems in a cost-effective manner.

Contained Rock Asphalt Mat Pavement System (CRAM)—a patented multilayered flexible road paving system that provides a full beam-like response to repetitive heavy wheel loads throughout the depth of the pavement.

Dye and Pigment Removal from Recycled Plastics via Selective Dissolution Process—a reclamation process for municipal plastic waste consisting of a series of selective sequential dissolution, filtration, and adsorption steps to remove pigment and dye coloring, thus upgrading the quality and value of the recycled plastic.

MODEL DEVELOPED FOR DIAMOND TURNING PROCESS

Undesirable vibrations of the tool-workpiece system in machining processes can adversely affect the machined part. In an effort to overcome this problem, two NIST researchers have developed a model for the diamond-turning process that takes into account the cutting forces that result from the geometry of the chip area cut by a round nosed tool. This work was performed in cooperation with a professor at the University of Maryland.

In their model, the chip area generated during the cutting action is approximated as a parabolic segment that is a function of the tool feed rate, the depth of cut and the current and previous tool-displacement histories. This leads to a system of retarded differential equations that is studied to determine the stability of the cutting process with respect to parameters such as feed rate, depth of cut, and spindle speed. The results are presented in the form of stability charts. For round nosed tools, these charts are found to be perturbed

forms of those obtained for orthogonal cutting tools. Furthermore, the findings indicate that for a fixed feed rate, the two most significant parameters that affect the stability regions are found to be the tool nose radius and the material damping ratio. The predicted stability results were found to be consistent with the experimental observations.

METHOD DEVELOPED FOR ELECTROCHEMICAL QUANTITATION OF SURFACE-IMMOBILIZED DNA

NIST scientists have developed an electrochemical method to quantify the amount of DNA immobilized on a gold surface. This technique has been developed as part of a program to characterize the behavior of surface-immobilized DNA, which is being used increasingly in the development of biochip sensors. The surface density of DNA is determined electrochemically using positively charged redox molecules that associate stoichiometrically with the negatively charged phosphate groups along the DNA backbone. Accordingly, the electrochemical method can be used to measure both single- and double-stranded DNA with equivalent sensitivity, an aspect that is not easily attained using conventional DNA quantitation methods. Also, because the electrochemical method is based on electrostatic interactions rather than intercalation or reactive labeling, the quantitation results are independent of the DNA base sequence and additional sample proc-essing is not required as is the case for fluorescence and radiolabeling determinations.

Gold surfaces decorated with single-stranded probe DNA were prepared using a method developed by NIST scientists. The surface density of molecules of probe DNA was precisely varied in the range of $5 \times 10^{11}/cm^2$ to $1 \times 10^{13}/cm^2$, as determined by the electrochemical method. The detection limit of the method is roughly $1 \times 10^{11}/cm^2$. Hybridization of complimentary target DNA to the immobilized probes displayed a peaked response as a function of probe DNA coverage. Hybridization efficiencies of nearly 100 % were observed for probe densities less than $4 \times 10^{12}/cm^2$. The results indicate that there is an ideal surface density of immobilized probe DNA for optimal DNA chip performance that is a function of the probe and target size.

STRUCTURE AND HYBRIDIZATION OF SURFACE-TETHERED DNA OBSERVED WITH NEUTRON REFLECTIVITY

NIST scientists are using neutrons to understand what happens when DNA tethered to a surface binds to its single-stranded complement. DNA immobilized on surfaces forms the operational heart of DNA microchips, devices that provide rapid screening of genetic information for medical, environmental, and forensic applications. From a technological perspective, the principal issue of interest is molecular recognition and binding of free single-stranded analyte, or "target", DNA by single-stranded, surface-tethered, "probe" DNA. To optimize probe/target recognition, the tethering of the probes to the substrate must be engineered so that it does not interfere with their ability to hybridize. In particular, it is expected that if the probes are attached to the substrate by one end only their accessibility to incoming target strands will be maximized. A convenient way to achieve such end-tethering is to chemically bond the DNA probes to gold surfaces through a thiol group located at one end of each probe strand. In addition, in a process recently patented by NIST scientists, the non-specific adsorption of the probe DNA at sites other than the thiol end-group can be minimized by co-adsorbing mercaptohexanol, a short alkanethiol molecule that also attaches to gold through a thiol group.

Neutron reflectivity was used to furnish direct, molecular-level proof of the success of the mercaptohexanol treatment in blocking undesirable probe/substrate interactions that would interfere with probe/target binding. Because the experiment determines the DNA concentration profile, neutron reflectivity can provide structural details about the DNA monolayers including the amount of DNA on the surface and how far the DNA extends into the solution. When thiol-terminated probes containing 25 bases were adsorbed to gold in the absence of mercaptohexanol, the probes extended only 1 nm into the surrounding buffer solution. This confined attachment confirmed the presence of multiple adsorption contacts between the probes and the substrate. Furthermore, the tightly bound probes exhibited poor binding with complementary targets. Co-adsorbing mercaptohexanol to the gold substrate led to an increase in the width of the probe concentration profile to approximately 5 nm and the profile shape became characteristic of flexible, end-attached chains. These dramatic changes provide direct evidence that the mercaptohexanol treatment lifts the probe backbones from the gold surface, leaving them anchored solely through the thiol-derivatized end. More importantly, it was then determined that nearly 100 % of the end-tethered probes hybridized with the complementary targets. The hybridized DNA extended approximately 8 nm into the solution, suggesting that the rigid double helices prefer a nearly perpendicular orientation to the gold surface. These preliminary findings highlight the unique capabilities of neutron reflectivity in providing molecular-level details about this important biomolecular system.

Volume 103, Number 2, March–April 1998
Journal of Research of the National Institute of Standards and Technology

OPTICAL WEDGE EFFECTS IN INSTRUMENTS AND STANDARDS FOR MOLECULAR ABSORPTION SPECTROPHOTOMETRY

The optical wedge of some older, solid, Standard Reference Material (SRM) absorbance filters has been found to cause bias in the indicated readings of spectrophotometers of a modern, wavelength-multiplexed design. These instruments are particularly suited to monitoring chemical and pharmaceutical process lines, as well as reaction kinetics, and constitute an increasing fraction of the installed base (presently estimated at about 20 %). NIST-issued and NIST-traceable solid reference material filters have been available for nearly 3 decades and are used widely by the chemical and pharmaceutical industries and recognized by regulatory agencies as the primary means of verifying the accuracy of UV/visible spectrophotometers. NIST scientists have investigated the wedge-induced bias to establish new production tolerances and testing procedures for solid absorbance standards.

In a collimated-beam instrument, the sample beam is deflected by about half of the wedge angle in the sample. For spectrophotometer designs with post-sample wavelength dispersion, such small deflections can give rise to large changes in the field of view of the spectrometer's entrance slit. Beam deflection also induces small apparent wavelength shifts in data taken through a wedged sample, resulting in artifacts derived from spectral features of the system or of an absorbing sample. These spectral artifacts turn out to be useful in diagnosing a wedged sample by means of simple sample-reversal difference spectra.

Solid photometric standards are reliable if manufactured with wedge angles of less than 0.1 mrad. Each standard is now tested for wedge using a pair of autocollimators, which have been calibrated against a mechanical comparator at NIST. Apparent wavelength shifts in the NIST holmium perchlorate wavelength standard are negligible with respect to the uncertainties stated despite a wedge tolerance of 0.9 mrad in the sealed cuvettes used. For normal spectrochemical absorbance measurements, accuracy may be achieved by utilizing a single sample cell in the same orientation for both the background and the sample spectra or by the selection of low-wedge cells using the sample reversal diagnostic.

WORKSHOP ON DEVELOPMENT OF STANDARDS FOR CONCRETE AND MASONRY STRUCTURES CONDUCTED BY NIST

On Jan. 7-8, 1998, NIST conducted a workshop on the development of standards for the use of fiber-reinforced polymer composite for repair, retrofit, and rehabilitation concrete and masonry structures. The workshop was held in Tucson, AZ, immediately following the 2nd International Conference on Composites in Infrastructure. The 30 invited participants represented industry, academia, and federal/state government agencies. Nine papers were presented in the plenary session to set the framework for the discussion.

Overall conclusions of the workshop were: (1) there is a need for national standards for the use of polymer composites to rehabilitate concrete and masonry structures; (2) there is a strong role for NIST to play in leading the development of measurements and design guidelines underpinning these national standards; and (3) NIST could contribute greatly in the area of fire resistance of polymer composites, as structural rehabilitation moves from highway bridges to buildings, where fire is a greater concern. Proceedings of the workshop will be prepared for distribution.

UNITED STATES/CANADA INTERLABORATORY COMPARISON COMPLETED

Manufacturers of thermal insulation in the United States and Canada require reliable thermal measurements to market their products effectively in both countries. The international trade of thermal insulation products between the United States and Canada currently represents a business of several million dollars. To further promote international commerce in this sector, NIST, in collaboration with researchers at the National Research Council Canada (NRC-Canada), have completed an interlaboratory study of guarded hot-plate measurements.

In this study, NIST and NRC-Canada measured the thermal conductivity of two thermal insulation materials; glass-fiber board selected from SRM 1450c and fibrous alumina silica. A single pair of specimens of each mate-rial was circulated to both laboratories and measurements were reported from 273 K to 340 K. The nominal bulk density and thickness for the specimens of glass-fiber board and fibrous alumina silica were 160 kg/m^3 and 25.1 mm, and 290 kg /m^3 and 25.2 mm, respectively. The analyses of the data at 297 K revealed a small difference, on the order of 1 %, for the data for glass-fiber board and no offset for the data for fibrous alumina silica. Before taking any action, NIST and NRC-Canada have agreed to participate in another international interlaboratory study with additional participation from national standards laboratories in France, Japan, and the United Kingdom.

COLLABORATION BETWEEN NIST AND PRIVATE COMPANY DEMONSTRATES CAPABILITY OF ION IMPLANTATION DOSE MEASUREMENTS

A collaboration between scientists from NIST and from a private company has demonstrated the repeatability and accuracy that can be achieved in making ion implantation dose measurements by secondary ion mass spectrometry (SIMS). Ion implantation of dopant species is a standard processing step in integrated circuit fabrication. The ability to monitor the implanted dose with low uncertainty is important for offline process control, for reliable transfer of processes among different production locations, and for comparison of experimental performance with process simulations. As a test of SIMS capability, three silicon wafers were implanted with BF_2 ions at three different doses differing by plus and minus 5 % from a nominal BF_2 ion dose of 10^{14}/ cm^2. Pieces of each wafer then were analyzed in a blind manner by SIMS at each facility to determine the number of implanted boron atoms per unit area. NIST SRM 2137, a boron-implant-in-silicon standard, was used by both laboratories as a dose calibration standard.

Using carefully designed measurement protocols, both laboratories were able to distinguish correctly the dose order of the three samples. The average dose agreement between laboratories was within 1.3 %. This is the best interlaboratory agreement for dose measurements by SIMS ever reported. Furthermore, the measured doses of all samples were found to be 15 % lower than the targeted doses, confirming a suspicion based on process simulation results. The use of SRM 2137 is the basis for the accuracy of the measurements and thereby adds strong credibility to this observation. Results of this study were reported at the International Conference on Secondary Ion Mass Spectrometry (SIMS XI) held in Orlando, FL, in September 1997.

NIST HOSTS ASTM WORKSHOP ON STANDARDS FOR TISSUE-ENGINEERED MEDICAL PRODUCTS

At an ASTM workshop, co-organized by NIST representatives from industry, universities, and government established 10 major task groups for the purpose of developing standards and standard protocols for tissue-engineered medical products (TEMPs). Of the 83 participants at the December 1997, meeting, 33 were from industry, 25 from academia, and the remainder were from government agencies, including the National Science Foundation, National Institutes of Health, the Food and Drug Administration (FDA), and NIST.

Tissue engineering is a rapidly emerging field that cuts across many disciplines. Because of the rapid pace of progress, development of standards or even standard protocols has lagged. Leaders in the field recognized that future advancements in the field and the introduction of commercial products will be impeded without consensus standards and test protocols. The impetus for standards for TEMPs began at the spring 1997 semi-annual meeting of the American Society for Testing and Materials (ASTM), in St. Louis, MO, with a workshop entitled "Workshop on Tissue Engineering: The Role of ASTM." Experts from academia, industry, and private-sector research institutions in the field of TEMPs, along with representatives from the FDA and NIST, were invited to present their views on the needs for standards for TEMPs. As a result, the ASTM Committee F04 chartered a new division, Division IV, at its next semi-annual meeting in November 1997. During the meeting, the needs for standards for TEMPs were prioritized and the following statement of scope was approved: "The development of standards and promotion of related materials for tissue engineered medical products focusing on components of combination medical products intended to repair, replace or regenerate human tissue. These comprise the biological components such as the cells, tissue, cellular products, and/or biomolecules and biomaterials used in combination, including biologic, biomimetic and/or synthetic materials. Division IV will work with other committees within ASTM and other organizations having mutual interests." The December 1997 meeting at NIST formalized the task groups under the new division.

FAST SPHERICAL FILTER GETS DIVERSE APPLICATION

An algorithm recently developed by researchers at NIST and the University of Colorado is receiving attention from diverse quarters in industry and government. Its applications range from microwave modeling in electromagnetics to weather and climate modeling.

The work, which was reported in the Journal of Computational Physics in September 1997, involved constructing a fast algorithm for obtaining a uniform resolution representation of a function known at a latitude-longitude grid on the surface of a sphere. For a grid containing N^2 points, the new spectral truncation method performs a projection to a uniform-resolution function space in time proportional to $N^2 \log N$, compared with N^3 for the equivalent projection via the spherical harmonics transformation. This represents a very significant cost reduction, allowing the practical solution of problems on much finer grids than previously possible.

For example, the new, fast algorithm reduces the computational complexity of the step that is a computational bottleneck in standard weather and climate models, and is being tested at the National Center for Atmospheric Research, Boulder, for integration into existing computational routines. In another case, an enhanced implementation of the algorithm built by researchers at Yale University is now used at an aircraft manufacturer in recently developed electromagnetics modeling software, where the current application is simulation of radar scattering and aircraft "signatures."

STUDY SCOPES SERVICE SECTOR TECH TRENDS, NEEDS

Service sector spending on information technology has paid off handsomely, yielding an estimated return of nearly 200 %. Yet, the complexity of computer networks, fear of being stranded with an obsolete system, and other issues breed indecision that sectorwide causes substantial underinvestment in new technology.

These and other findings are reported in a new NIST-sponsored study of the sources and uses of advanced technology in the service sector—by far the largest and fastest growing segment of the U.S. economy. Commissioned by NIST to help guide its strategic planning, the study reviews a range of economic data and contains case studies of technology trends in the retail banking, home entertainment and health care industries.

For the sector as a whole, information technology accounts for more than 80 % of technology spending, mostly for integration and tasks focused on implementing new hardware and software. Spending on research and development has increased in recent years—especially in the computer and communications services industries but the sector primarily imports its advanced technology from other industries.

The study identified 19 technology needs and issues common to two or all three industries that were studied in-depth. These include support for electronic commerce applications, cryptographic standards, network scaling, data compression, wireless communication, distributed databases and multimedia quality of service tools.

"One conclusion stands out," says a NIST senior economist, "whatever the structure and content of service-sector technology, it has a systems character. This creates substantial technical infrastructure needs."

To request a single copy of "The Economics of a Technology-Based Service Sector" (NIST Planning Report 98-2), contact Denise Herbert at (301) 975-2657, dherbert@nist.gov.

NIST SHORT COURSE YIELDS BETTER TEMPERATURE MEASURES

Industrial managers and engineers know that the accuracy of temperature measurements has a big impact on the quality of products and the efficiency of processes. In order to help industry improve temperature measurement accuracy, NIST is offering a new short course, Temperature Measurement by Radiation Thermometry, from June 1-5, 1998. The course can accommodate 16 students and will be taught annually.

Course lectures will cover the fundamentals of radiometry, a non-contact method for surface temperature measurement used widely in industrial applications and materials research. Laboratory experiments with a student-to-teacher ratio of four to one will provide ample opportunity to try out the skills learned.

The fee for the course is $1230.

For registration information, contact Lori Phillips, B116 Administration Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-3881, fax: (301) 948-2067, lori.phillips@nist.gov. For technical information, contact Carol Johnson, B208 Physics Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-2322, fax: (301) 869-5700, cjohnson@nist.gov.

EMAT APPLIED TO MAGNETOSTRICTION OF METALS

NIST has pioneered the use of electromagnetic acoustic transducers (EMATs) to inspect metal sheets on the production line. EMATs provide a means for generating and detecting ultrasound in metals without touching the sheets. The technique has been used to measure key features of magnetostriction, the change in length of a ferromagnetic material that accompanies a change in magnetization. Further development may allow EMAT measures of magnetostriction in situations where it is not practical to attach strain gages, such as with fragile thin films or hot plates. It also may be used to monitor microstructural changes in steel.

In one study, NIST researchers were able to detect the coarsening of copper precipitates in A710 steel. Therefore, it may be possible to use EMATs online as a nondestructive test for determining when the toughness of this steel is optimal. A future study will try to determine whether this technique can be used to sense the formation of fine copper precipitates that can reduce the ductility of reactor pressure vessel steels.

Three technical papers (combined in a set as no. 3-98) that discuss the EMAT technique and magnetostriction are available from Sarabeth Harris, MC 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, sarabeth@boulder.nist.gov.

NIST AND PRIVATE COMPANY EXTEND CRADA ON GALLIUM NITRIDE FILMS

NIST and a private Boulder, CO company recently signed a document extending their cooperative research and development agreement to process gallium nitride films on silicon carbide and sapphire substrates for use in industrial devices. Gallium nitride and its alloys are important to NIST because they can be made into light-emitting diodes and diode lasers in the green-to-ultraviolet range of the spectrum. Industrial interest is high because of applications in display technology, optical memory and specialty detectors and transistors.

Building upon work conducted under the original partnership, the CRADA extension will enable NIST personnel to develop a basic understanding of gallium nitride processing and device development. The new project will focus on the development of transistors designed for high temperature operation and solar-blind ultraviolet detectors. The CRADA partners hope to take these devices from the current exploratory stage to a successful demonstration. Once that goal has been reached, the company will assume full responsibility for production of the gallium nitride devices.

For more information, contact Kris Bertness, NIST, MS 815.04, Boulder, CO 80303-3328, (303) 497-5069, bertness@boulder.nist.gov.

PARTNERS FILL BIG NEED WITH BETTER SRMS FOR SHRINKING CHIPS

In an effort to keep up with the galloping pace of technological change in the semiconductor industry, NIST has teamed with a private company to improve the availability of thin-film reference materials tailored for industry. Through a cooperative research and development agreement, NIST worked with the company to establish a traceability pathway to NIST standards for the company's new 4.5 nm and 7.5 nm thin-film reference materials.

Made of silicon dioxide, these thin films are needed by the semiconductor industry to calibrate ellipsometers used for process development and process quality control when making very large-scale integrated circuits. NIST enabled the company to establish its measurement "traceability" by carefully characterizing the company's current thinnest reference materials with NIST's primary, high-accuracy ellipsometer. Currently, the thinnest silicon dioxide Standard Reference Materials available from NIST are 10 nm thick, provided on wafers with 76 mm diameters.

The private company's new reference materials will be provided in 150 mm and 200 mm diameter wafers currently more common in industry.

For more information, contact Barbara Belzer, NIST, (301) 975-2248.

SEVEN TRAPPED IONS MAKE A BETTER CLOCK

The key to improving atomic timekeeping is the ability to better determine the frequency of the atoms involved. The more atoms that you have and the longer you can observe them, the better that ability grows. Currently, the best cesium-beam clocks are limited by the fact that atoms speed through the apparatus at bullet-like velocities, giving the scientist only a fleeting glance at each one. A new technique called the atomic fountain gently tosses the atoms straight up and lets them fall back through the measuring apparatus. This extends the observation time and greatly improves the clock's performance.

NIST scientists studying a promising alternative: trapping the atoms in a net of electromagnetic waves and then laser cooling them to near absolute zero. This would allow the atoms to be scrutinized for much longer periods than are currently achievable. In addition, trapping and cooling many atoms instead of just a few will greatly strengthen the signal.

NIST researchers have succeeded in trapping seven mercury atomic ions and examining them for up to 100 seconds at a time. This allows their characteristic frequency to be determined with an accuracy and precision that approaches the best results yet obtained from atomic fountains. Hopefully, the technique can be extended to collections of several dozen ions, so that the next generation mercury ion clock may surpass even the cesium fountain's performance.

A paper, no. 12-98, describing the work is available from Sarabeth Harris, MC 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, sarabeth@boulder.nist.gov.

COMMENTS ON SOFTWOOD LUMBER STANDARD SOUGHT

Voluntary Product Standard PS 20-94, American Softwood Lumber Standard, is used by the softwood lumber industry to provide for uniform, industry-wide grade-marking and inspection requirements for softwood lumber here and abroad. In addition, it serves the procurement and regulatory needs of numerous Federal, state and local government agencies. The implementation of the standard also allows for uniform labeling and inspection of treated wood products.

As part of the 5-year review of the standard, NIST is seeking public comment on the standard during the next 3 months.

The American Lumber Standard Committee, the standing committee that is responsible for maintaining and interpreting PS 20-94, will assist NIST in determining the technical adequacy of the standard, the level of

acceptability the standard has among the various segments of the softwood lumber industry, the standard's compatibility with existing law and established public policy, and the benefits that would be derived from PS 20-94 versus any alternatives. Upon completion of the review, the ALSC and NIST will reaffirm, revise or withdraw PS 20-94 as appropriate.

Comments on PS 20-94, supported by data, views or arguments, should be submitted to NIST no later than June 30, 1998.

Comments may be sent to Barbara M. Meigs, Rm. 164, Building 820, NIST, Gaithersburg, MD 20899-0001, fax: (301) 926-1559, barbara.meigs@nist.gov. The text of PS 20-94 may be found on the World Wide Web (as an Adobe Acrobat file) at http://ts.nist.gov/ts/htdocs/210/215/ps20-94.pdf. For those without access to the Web, a printed copy may be obtained from the address above.

NIST LAB UPGRADES SCIENTIFIC DATA ON THE WEB

NIST World Wide Web pages offering free and easy access to scientific data are among the Institute's most popular, getting thousands of "hits" per month from computer users around the world. Now NIST has improved, expanded and integrated the data offered on some of these pages into a new easy-to-use site: http://physics.nist.gov/cuu. This public resource provides in-depth information on the fundamental physical constants, the International System of Units (the modern metric system known as SI) and the expression of uncertainty in measurement.

Any computer user with access to the Web can use this site to look up values of fundamental physical constants and conversion factors of physics and chemistry. These values are searchable in an easy-to-print form.

The metric information section contains a concise summary of the essential features of the SI, and the rules and style conventions for its use. In addition, the section details the seven SI base units and the 21 SI-derived units with special names and symbols. Electronic publications discussing use of the SI are also available.

The section concerning uncertainty covers evaluating and expressing the uncertainty associated with measurement results. A helpful publication from NIST and the citations of related publications of the International Organization for Standardization are posted in this section.

PARTNERS CREATE NEW DETECTOR FOR FIBER POWER MEASUREMENTS

Scientists at NIST and two private companies have designed and built an optical detector that can be used for the calibration of optical fiber power meters that incorporate various types of fibers and fiber connectors. The new device provides a convenient means for high-accuracy optical radiation measurements where a large numerical aperture is needed.

The detector was evaluated at NIST's calibration facility and then tested by one of the companies in a production measurement environment. The three partners believe the detector could serve as a viable commercial product for many U.S. businesses that manufacture and measure fiber optic/optical communication test equipment.

Technical information is available from John H. Lehman, MC 815.01 NIST, Boulder, CO 80303-3328, (303) 497-3654, lehman@boulder.nist.gov. A paper, no. 11-98, explaining the detector is available from Sarabeth Harris, MS104, NIST, Boulder, CO 80303-3328, (303) 497-3237, sarabeth@boulder.nist.gov.

TENSILE TESTING OF THIN FILMS SHOWCASED IN REFERENCE SET

Since all microchips contain thin films, it is critical that manufacturers be able to assess their reliability. If the mechanical properties of the films themselves or their interfaces to other materials fail, then the electrical function of the devices they support will fail as well. Unfortunately, traditional mechanical test techniques are not suitable for these thin films.

NIST recently published a collection of five technical papers about the development of a set of techniques for measuring the tensile properties of thin films. In this reference, the term thin films means metal layers produced by physical vapor deposition or electrodeposition, with thicknesses around 1 μm. The described apparatus tests specimens whose gauge section is typically 0.8 mm long and 50 μm to 200 μm wide. Specimens with thicknesses ranging from 0.3 μm to 15 μm have been tested.

Topics discussed in the papers include "A New Method for Measuring the Strength and Ductility of Thin Films," "Mechanical Behavior of Aluminum and Copper Thin Films," "Fatigue of Microlithographically Patterned Free-Standing Aluminum Thin Film Under Axial Stresses," "Tension-Tension Fatigue of Copper Thin Films" and Piezo-Actuated Microtensile Test

Apparatus." Also included are detailed mechanical drawings of the piezo-actuated microtensile test fixture and the current versions of the software used to control the tensile tests and reduce the data.

For copies of Tensile Testing of Thin Films: Techniques and Results, contact David T. Read, MC 853.08, NIST, Boulder, CO 80303-3328, (303) 497-3853, read@boulder.nist.gov.

NIST ADDS THREE CRYPTOGRAPHIC MODULES TO THE FIPS 140-1 VALIDATED PRODUCTS LIST

In Jan. 1998, NIST validated three new commercial cryptographic modules for use by Federal agencies. These modules were validated as conforming to FIPS 140-1, Security Requirements for Cryptographic Modules. FIPS 140-1 specifies four separate levels of security provided by cryptographic modules, with each level providing increased security and assurance. This series of validations brings the total number of validated products to 15 for NIST's Cryptographic Module Validation (CMV) program. Many new modules are expected to be validated over the next several months.

The CMV program is a joint effort between NIST and the Communications Security Establishment (CSE) of the Government of Canada. NIST and the CSE serve as the validation authorities for the program. Currently, there are three National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratories that test cryptographic modules.

These new validations impact federal agencies by increasing the number of cryptographic products available for use in securing sensitive information.

NEW MEASUREMENT TECHNIQUES WILL IMPROVE SHEET METAL FORMING

Metal forming is an enormous industry in the United States, with value-added amounts in the tens of billions of dollars annually. The automobile industry is the largest user of sheet metal; sheet metal products constitute approximately 33 % of the weight of an automobile. Driven by a need to decrease both cost and product development times, industry is increasingly relying on finite element method (FEM) computer codes to design metal-forming operations. These FEM codes require accurate mathematical models, called constitutive laws, describing the mechanical response of a metal-to-plastic deformation. Unfortunately, existing models are only accurate enough to provide a rough guide in designing a forming operation. Researchers working on the Light Weight Materials for Automotive Applications program at NIST have made a major advance in the quest to develop new constitutive laws that are based upon a fundamental understanding of deformation physics. Improved constitutive laws are particularly important for modeling the behavior of lightweight metals such as aluminum alloys that are needed to build lighter cars with greatly improved mileage and reduced emissions.

The changes in the mechanical properties of metals that occur during plastic deformation are caused by the evolution of complicated three-dimensional structures of defects called dislocations. Although this phenomenon has been extensively studied for more than 70 years, the evolution process is so poorly understood that disagreement exists on even the most basic qualitative level. Without such knowledge, the development of physics-based constitutive laws is impossible. The main reason why progress in this field has been so slow is that no measurement techniques existed for measuring dislocation structure evolution in bulk metal samples. NIST researchers have now developed two complementary experimental techniques that can study dislocation structures in situ in samples as thick as 1 mm. These techniques, in situ high-resolution diffraction imaging and in situ ultra-small-angle x-ray scattering (USAXS), are being used at the NIST materials science beamline at Brookhaven National Laboratory's National Synchrotron Light Source to study dislocation structure evolution in deforming single-crystal aluminum.

In the diffraction imaging measurements, intense monochromatic x rays are used to directly image the dislocation structures in 1 mm-thick metal samples. Stereo pairs allow three-dimensional information to be obtained. In the USAXS measurements, x-ray scattering data are obtained from 0.15 mm-thick specimens. Meaningful interpretation of these data required the development of a new theoretical model of small-angle scattering from dislocation structures. Additional complementary experimental techniques are still in development.

NIST DEVELOPED A PRESSURE DROP MODEL TO HELP THE AIR-CONDITIONING INDUSTRY

NIST researchers have developed a simple correlation to predict the two-phase pressure drop for refrigerant/lubricant mixtures in smooth and micro-fin tubes. Prior to this research, a pressure drop correlation did not exist in the open literature that industry could use to predict the effect of lubricant on the pressure drop in refrigera tion systems. All air conditioners and heat pumps operate with dilute solutions of refrigerant/lubricant mix-

tures. The viscosity of the lubricant is large relative to the refrigerant viscosity. Consequently, the lubricant can significantly increase the pressure drop relative to the pure refrigerant pressure drop. Although the pressure drop phenomenon is complex, the heat exchanger designer now has a new tool that simplifies the design process.

NIST ROCKWELL HARDNESS INDENTER TO BE USED AS AN INTERNATIONAL COMMON INDENTER

Rockwell hardness is the most widely used mechanical testing method for metal products. Currently used national Rockwell diamond indenters in different laboratories show significant differences in their microform geometries that result in nonunified Rockwell hardness scales in different countries. In 1994, NIST established a microform calibration system with the highest accuracy for calibrating the Rockwell indenters. NIST also proposed a metrology approach using NIST-standard indenters to unify international Rockwell hardness scales. Since 1995, NIST has calibrated more than 80 Rockwell indenters from five different countries. Among these indenters, a group of nine indenters showed the best geometries as well as consistent hardness performance. One of them has been used as the NIST master standard for calibrating 300 NIST standard reference material (SRM) Rockwell hardness blocks.

Based on the NIST approach, an international round robin was started in 1997 aimed at establishing a world-wide-unified Rockwell hardness scale. Thirteen national laboratories are participating. At the kickoff meeting held in October 1997, two Rockwell diamond indenters from two other national laboratories were nominated as candidates for the international common indenter. These two indenters were brought to NIST for geometrical calibrations. Since the calibration results showed that the microform geometries of both indenters are not qualified, NIST was invited to provide a geometrically qualified indenter as the international common indenter. A NIST indenter, selected from the group of nine NIST indenters previously established, is planned for use as the international common indenter for a laboratory inter-comparison to establish the worldwide unified Rockwell hardness scale.

NOVEL SPECTROSCOPY OF A BIOMOLECULE AT A SURFACE OBSERVED AT SURF

Various spectroscopies have been used to investigate proteins and nucleic acids when they are immobilized on surfaces where their activity can be exploited in applications ranging from detection and screening to catalysis. Recently, NIST scientists used the SURF UV light source to measure shifts in the electronic absorption spectra of the molecule tryptamine in response to small perturbations of the electric field on a polycrystalline gold electrode where it was chemically immobilized.

Tryptamine is similar to the amino acid tryptophan; both have an indole-like structure with very strong electronic absorption bands at 218 nm. The shift in the electronic absorption spectrum, known as the Stark shift when it is brought about by change in an external electric field, was observed in electroreflectance (ER) measurements which are used by the investigators to study protein electron transfer at electrodes. They combined measurements of surface concentration (ellipsometry), tryptamine molecular orientation (surface-enhanced Raman scattering), along with ER measurements in several different ionic strength buffers (interfacial electric field variation), in order to isolate and extract the Stark shift. (The Stark shift is very small and results from the difference in the dipole moments of the electronic excited and ground states of the tryptamine.) Together, the measurements led to a model of "immobilized" tryptamine consisting of a first layer of tryptamine molecules that are covalently bound to the gold surface through the modifier.

A second layer of tryptamine is associated with the first layer through the indole rings so that the second layer is "upside down" on the first layer. The general application of the measurements described above will be significant for the study of potential-induced structural changes of adsorbed proteins that have a tryptophan as an integral part of their structure. The work will be published in the Journal of Colloid and Interface Science. Future work at SURF will include assessing the potential of the Stark shift as an indicator in structural changes of tryptophan-rich proteins which are subjected to external forces due to interfacial electric fields.

NEW FACILITY COMMISSIONED TO INVESTIGATE HEAT TRANSFER PHENOMENA IN SUPERCRITICAL FLUIDS

Researchers have commissioned a new experimental facility for studying heat transfer phenomena in flowing supercritical carbon dioxide. Supercritical fluids have become increasingly important as alternative fluids in modern technologies such as destruction of organic wastes, chemical synthesis and extraction, precision cleaning, and as working fluids in refrigeration and heat pumps. Because the properties of a fluid vary considerably with small changes in the thermodynamic state near the critical point, flow behavior and the transport of heat are very different in this regime and must be studied carefully to develop accurate predictive methods for process design.

The facility, as presently configured, will test a counterflow heat exchanger, which is a fundamental process unit in many industrial applications. The supercritical carbon dioxide flows inside a 2.74 m long by 10.9 mm ID horizontal tube, and is heated by hot water flowing on the outside of the tube. Operating pressures are adjustable from slightly above the critical (7.38 MPa) to 14 MPa, inlet temperatures can be varied from 0 °C to 30 °C, and the outlet temperature will be above the critical temperature (31.1 °C). The inlet Reynolds number can be varied from 10^4 to 10^5. A unique feature of the facility is an optical cell which maintains the flow and heat rate to the carbon dioxide while allowing visualization and probing of the flow patterns. Measurements of the thermal performance of the heat exchanger and an understanding of the underlying physical phenomena will be used to improve design and performance prediction tools for industrial processes utilizing supercritical fluids.

NEW RADIATION DOSE CALIBRATION SERVICE

NIST researchers have developed an improved technique to measure absorbed dose in radiation therapy. Measurements of absorbed dose for the more than 600 000 U.S. patients per year undergoing external-beam radiation therapy for cancer treatment are traceable to NIST standards for ^{60}Co gamma rays. The ionization chambers used in such measurements are currently calibrated in terms of exposure (the ionization of air), and a series of calculations must be performed to convert the measured exposure in high-energy electron and photon therapy beams to absorbed-dose-to-water (the standard tissue substitute). The international trend is to calibrate ionization chambers directly for absorbed-dose-to-water, removing much complexity in clinical dosimetry. The American Association of Physicists in Medicine (AAPM) is collaborating with NIST to implement a new North American protocol based on such calibrations.

NIST has developed a water calorimeter which directly realizes the quantity of interest and which serves as NIST's primary standard for absorbed-dose-to-water. NIST and the AAPM have agreed that small ionization chambers, of the type currently in use at radiotherapy facilities, can be used as secondary standards to transfer primary standard measurements made in the NIST ^{60}Co beam at a depth of 5 cm in water. Such transfer standards will permit secondary dosimetry calibration laboratories (accredited by the AAPM) to offer NIST-traceable calibrations by summer 1998.

To confirm the accuracy of these methods, two ionization chambers were sent to the International Bureau of Weights and Measures (BIPM) for an indirect comparison with international absorbed-dose-to-water standards. Preliminary results indicate agreement between NIST and the BIPM to within 0.4 %. Bilateral international comparisons are being planned with a number of national laboratories, including the National Research Council (Canada), National Physical Laboratory (Great Britain), and Physikalisch Technische Bundesanstalt (Germany).

MODIFICATION OF LASER-PRODUCED NANOSTRUCTURES

Researchers at NIST recently established a new technique for nanofabrication using the nodes of a laser standing wave to focus chromium atoms into tiny lines and dots as they deposit onto a surface. In a new extension of this work, researchers have shown that reactive-ion etching can covert the chromium features into a variety of interesting nanostructures, ranging from narrow trenches in the silicon substrate to well-defined chromium nanowires on top of sharp silicon ridges.

In the original process, the laser standing wave creates a periodic array of "atom lenses" with 213 nm spacing. These lenses use light force exerted by the near-resonant laser light to focus atoms into dots or lines as narrow as 30 nm. The resulting structures can be very useful, for example, as a nanoscale pitch standard or as a template for a sensor array. One potential drawback of the structures is that there is generally some background chromium deposition between the features.

Describing their results in a recent publication [Appl. Phys. B 66: 95 (1998)], the researchers show how this background material can be removed through a reactive-ion etch process. Working with scientists at the University of Maryland, they have found that by carefully controlling the etching process and the contrast of the chromium lines, different types of structures

can be created. These can be narrow trenches about 80 nm wide; well-separated, evenly spaced chromium ribbons; or well-defined chromium nanowires with diameters of about 68 nm sitting on sharp silicon ridges.

Besides demonstrating new nanostructures, the introduction of reactive-ion etching for post-processing of laser-focused atomic deposition opens a number of possibilities for nanofabrication in a wider range of materials. By choosing specific materials for the substrate, and/or a possible interlayer between the substrate and the chromium, many options could be made available. Thus the inherent capabilities of the laser-deposition process, which include parallel fabrication with high resolution and high spatial coherence, can now be implemented in a broader variety of ways.

RECHARACTERIZATION OF THE NIST THERMAL TRANSFER STANDARDS CARRIED OUT FOR CCE INTERCOMPARISONS

During 1997 extensive recharacterizations of the frequency coefficients of NIST thermal converter standards for ac-dc difference have been carried out. Over frequencies ranging from a few hertz to above 100 MHz, ac voltage is most accurately measured in terms of a known dc voltage by an ac-to-dc transfer process using thermal transfer standards having known ac-dc differences. The NIST thermal transfer standards of ac-dc difference rely on special, coaxially constructed thermal voltage converters (TVCs) to determine the frequency response in the range from 10 kHz to 1 MHz. NIST is currently participating in various international comparisons under the auspices of the Consultative Committee on Electricity and Magnetism (CCEM). One comparison concerns the ac-dc difference of thermal voltage converters at input signal levels of 3 V and 4 V rms. In order to submit the best results, rebuilt versions of these converters have been assembled and a complete redetermination performed on the NIST standards of ac-dc difference in this frequency range.

The special converters consist of vacuum thermoelements and series resistors mounted in a cylindrical structure. The series rod resistors are carefully assembled from carbon-coated ceramic rods and copper end caps. All dielectric material external to the resistor is removed to eliminate (essentially) dielectric loss effects. No magnetic material is used in the resistor, surrounding coaxial structure, or thermoelement leads in order to reduce errors due to skin effect. Ultra-high-frequency patterned thermoelements are chosen to maintain the coaxial geometry. The ac-dc differences of these special TVCs are nearly independent of frequency from 10 kHz to 1 MHz. By characterizing them at 10 kHz in terms of the NIST primary standards, the frequency responses of the reference and working standard TVCs can be determined.

The complete procedure to recharacterize several ranges of the NIST working and reference standard TVCs was carried out using three of the special converters. Relative uncertainties (coverage factor of two) ranged from a few times 10^6 at 100 kHz to about 20×10^6 at 1 MHz. Changes (since the last recharacterization effort) in the ac-dc difference of the NIST standards in this frequency range were well below the claimed uncertainties.

CHARGE NOISE IDENTIFIED AS BARRIER TO SET DEVICE OPERATION

A team of NIST scientists, have shown that the problem of charge offset noise in single-electron tunneling (SET) devices, even operating at a temperature near absolute zero, is much more widespread than previously believed. These studies are important because the static charge offset appears to preclude the integration of SET devices, and in particular, to be a barrier to the parallel operation of a large number of single-electron pumps, which would otherwise offer an avenue to a large, metrologically useful current standard. Also, the time-dependent charge offset noise limits the sensitivity of SET transistors; this phenomenon has an important effect on the resolution of the charged-capacitor experiment currently being pursued by NIST scientists as a potential new capacitance standard.

In previous work by the NIST team (published in Physical Review B in 1997), measurements of the time-dependent noise at very low temperatures were performed (in particular, time-dependent current fluctuations between one of two discrete values, often called two-level fluctuator [TLF] noise). In that case, the voltage dependence of the TLF time dynamics clearly showed that the noise-producing defects were located outside the tunnel junctions, probably in the substrate. In their most recent work, the team has made measurements of noise in a new SET transistor and seen compelling evidence that, for this experiment, the opposite was true; i.e., the voltage dependence of the TLF time dynamics shows that the noise-producing defect is in the tunnel junctions. This work was carried out at the University of Maryland, in collaboration with workers from the university's Center for Superconductivity Research. It is widely believed that, akin to the behavior seen in most microelectronic devices, charge offset results from trapped charged structural defects in insulating regions of the device, such as the tunnel junctions or the substrate. It then follows that the noise is due to

motion of the defect in the disordered environment. The new results show that the dominant noise mechanism depends crucially on the microstructure of the thin-film materials used to fabricate the devices. Information about the time dynamics of defects derived from both sets of experiments forms the basis for further research toward understanding the source of this limiting noise, especially as it applies to electrical metrology.

INTELLIGENT MANUFACTURING SYSTEMS (IMS) MISSION CONSORTIUM FORMED

IMS International Steering Committee has officially endorsed the Modeling and Simulation Environments for Design Planning and Operation of Globally Distributed Enterprises (MISSION) Project. MISSION is a multi-national IMS project focusing on integration of manufacturing simulation systems and involves the efforts of researchers in more than 17 countries. NIST is taking a lead role in the IMS MISSION with a NIST scientist serving as U.S. coordinator for the project. A planning meeting was held with the Japanese delegation at NIST in January 1998. At the meeting, issues regarding the Consortium Cooperative Agreement, future plans, and schedules of the MISSION program were discussed.

NIST AND INDUSTRY WORK TOGETHER TO DEVELOP A PROTECTION PROFILE FOR ROLE BASED ACCESS CONTROL (RBAC)

In January 1998, NIST brought together the testing and evaluation community and information technology vendors to advance the development of a Role Based Access Control (RBAC) Protection Profile (PP). The purpose of the workshop was to discuss remaining issues that relate to the technical make-up of the Draft RBAC PP and to discuss Common Criteria evaluation expectations.

RBAC is an access control and authorization management technology that was modeled, developed, and transferred to industry by NIST. A Protection Profile is an internationally recognized Common Criteria standard for specifying security requirements that can be used as a basis for subsequent product or system evaluation.

NIST AND INDUSTRY COLLABORATE ON INTEROPERABILITY TESTING

In February 1998, NIST hosted a SMIL [Synchronized Multimedia Integration Language of W3C (World Wide Web Consortium)] interoperability test. The meeting brought together the major industrial implementors to evaluate their SMIL players against the predefined test scenarios. All SMIL players were based on the initial SMIL 1.0 draft, which was released to the public in November 1997 by the SYnchronized MultiMedia (SYMM) working group of W3C.

NIST and industry partners conducted the testing using the SMIL interoperability test by CWI (National Research Institute for Mathematics and Computer Science in the Netherlands) and a private company, along with a series of SMIL-related demonstrations from Real Network, NIST, and Talking Books. NIST created a SMIL feature-list Web site to allow each implementor to dynamically update its player capability. The meeting continued with feedback from the implementors on the SMIL 1.0 draft and planning for a future draft.

RAPID THERMAL PROCESSING ADVISORY GROUP MEETS AT NIST

NIST is exploring new methods to accurately measure the temperature of silicon wafers undergoing rapid thermal processing (RTP) for semiconductor device manufacture. The semiconductor industry projects that RTP will largely replace batch-diffusion furnace processing for various thermal processing steps as device-critical dimensions continue to shrink. Existing thermometry technology is inadequate for the stringent process control required for future RTP, and has been identified as a potential "show stopper" in reaching next-generation semiconductor roadmap goals. The NIST RTP thermometry project uses new thermocouple technology combined with improved radiation thermometry and heat transport modeling to make absolute temperature measurements in a research RTP reactor similar to fabrication reactors.

To ensure dissemination of NIST research results to the semiconductor community, and to guide NIST research, the NIST RTP Advisory Group was formed in January 1997. The group's second annual meeting was held at NIST in January 1998. About 40 people attended, representing RTP tool manufacturers, RTP users, RTP accessory instrument makers, academia, Sematech, and NIST. Recent NIST progress was discussed, including upgrades of the RTP research sensor test bed, and award of NIST CRADAs (Cooperative Research and Development Agreements) and university grants to promote the modeling and analysis of reactor heat flux and radiation thermometer performance. The meeting helped determine the direction for NIST research in the next year.

Another significant outcome of the meeting is the growing awareness in the RTP community of the need for accurate absolute thermometry. Until recently,

much of the community had pushed only for reproducible results specific to different kinds of processes and tools, with little appreciation of the benefits of absolute measurements. Through the RTP project, NIST researchers are beginning to demonstrate the need for and benefits of absolute thermometry for both process control and meaningful modeling.

NIST AND THE U.S. AIR FORCE EXPLORE NEW FIRE SUPPRESSION TECHNOLOGY FOR AIRCRAFT

Fuel spray fires in engine nacelles are of concern to both military and commercial aviation. The current suppressant of choice is halon 1301, CF_3Br, a chemical which is out of production due to its deleterious effect on stratospheric ozone. NIST engineers have been working with engineers at Wright Patterson Air Force Base (WPAFB) to test several approaches to suppressing these fires, with and without a fuel re-ignition source. The test includes two generic types of solid propellant gas generators (SPGG) similar to those used to inflate automobile air bags. One type produces inert gases only; the other inert gases plus potassium carbonate powder, an efficient fire suppressant. Early versions of this type of device already are being installed on preproduction military aircraft. While demonstrating some effectiveness, they also have presented problems that need to be overcome with a next-generation design. Well-instrumented tests in the WPAFB engine nacelle simulator have produced insight into the mechanisms by which SPGGs suppress the flames. The NIST team has developed a simple model of the SPGG delivery. Assuming plug flow of the SPGG effluent, average agent concentrations are calculated as a function of time in the nacelle. The agreement with the experimental measurements is reasonable. Under the DoD Next-Generation Fire Suppression Program, NIST will now develop a screen test for suppression delivery methods like SPGGs.

POST-EARTHQUAKE FIRES AND LIFELINES

Post-earthquake fires pose a significant threat to life safety and property and have detrimental environmental consequences. After the 1994 Northridge, CA earthquake, NIST researchers held a workshop with experts from utilities, local, state, and Federal government, universities, and professional societies to discuss the critical issues related to post-earthquake fires and lifelines (utilities and transportation systems). They also identified research areas that needed immediate attention. NIST scientists, in collaboration with several universities and private-sector organizations, undertook a number of studies. Several studies have been completed, and others are still in progress. Those completed include (1) seismic risk analysis of liquid fuel systems; (2) performance of petroleum storage tanks during earthquakes; (3) reliability and restoration of water supply system for fire suppression and drinking purposes following earthquakes; (4) fire hazards and mitigation measures associated with seismic damage of water heaters; and (5) analysis of fire sprinkler systems performance in the Northridge earthquake.

The studies recommend mitigation measures that will reduce the failure and disruption of lifelines during earthquakes. These studies will ultimately be used by the private and public sectors in formulating guidelines and standards for seismic design of lifeline systems.

IMPROVED VARIABLE-AIR-VOLUME AIR-HANDLING UNIT CONTROL

Collaboration between NIST, a private company, and the Iowa Energy Center has resulted in the development of a new damper control strategy that helps prevent outdoor air from entering a building variable-air-volume (VAV) air-handling unit through the exhaust air outlet. This problem has potentially serious ramifications for indoor air quality if the exhaust air outlet is located near a pollution source, such as a truck loading dock. Initial research performed by NIST engineers involved the discovery and analysis of conditions that can lead to the phenomenon in VAV systems. Subsequent research, performed under a CRADA with a private company, led to the development of the new control strategy. The new control strategy was validated by field studies performed at the Iowa Energy Center Energy Resource Station. An article describing the new control strategy was published in the February 1998 issue of the ASHRAE Journal.

JOINT ARMY/NIST RESEARCH ON NEUTRON PROBES FOR SAPPHIRE WINDOWS

Accidental initiation of propellants in large caliber munitions has been a concern of the military for a long time. A possible solution for this problem consists of replacing the shock-sensitive primers, which have been used for decades, by laser ignition of the propellant. However, in order to use the laser technique, a window is required that will efficiently transmit the light (whose source exists outside the cannon) and withstand the temperatures (3000 K) and pressures (344 MPa) without failing. The material of choice for this application is single-crystal sapphire because of its high mechanical

and thermal shock durability. Several sources for this material had been investigated with unsatisfactory results. Compression-induced twinning can lead to cracking of the window and failure well short of the mandated 300 high-pressure cannon firings. Although several methods had been tried to identify suitable material, none proved reliable. Finally, neutron small angle scattering was used to identify flaws and imperfections produced in the crystal growth process that could ultimately lead to failure of the sapphire windows. These measurements on the sapphire windows suggested that sapphire specimens grown using the heat exchange method (HEM) had an extremely high degree of crystal perfection and low levels of imperfections. These properties might inhibit twinning and early window failure. HEM-grown sapphire was selected as a window substrate standard and a truncated conical window geometry was designed which would minimize plane slippage under high-pressure loading. These windows have easily exceeded the required 300 high-pressure gun firings. These results also point the way to the use of cold neutrons as a powerful quality control tool in civilian technology involving laser-transparent materials and in communications applications.

PRECISION ENGINEERING DIVISION STAFF REPRESENT NIST AT ISO TECHNICAL COMMITTEE 213

ISO Technical Committee (TC) 213 on Dimensional and Geometrical Product Specifications and Verification recently held its semiannual meeting in Florida. This ISO committee, formed in June of 1996 from two other committees and a subcommittee, has responsibility for a wide range of standards in the fields of dimensional metrology, mechanical drawing, and surface metrology.

At the meeting, a number of NIST scientists contributed reports and expertise. One of the NIST scientists was an official delegate to the main committee and also delivered a report as the committee's liaison to ISO TC 172 on optics and optical instruments. He also delivered two other reports. One dealt with the need and opportunity for an instrument classification standard on surface texture, and the other dealt with the early progress to develop a standard for dimensional inspection information exchange under another ISO committee (TC-184) as part of the Standard for the Exchange of Product Model Data (STEP).

As a U.S. subject matter expert, another NIST scientist participated in ISO's Working Groups (WGs) on Coordinate Measuring Machines (CMMs) and on Uncertainty of Measurement and Decision Rules. He was selected to chair the Strategic Planning Group for the WG on CMMs. The Strategic Planning Group sets the agenda for both the existing ISO 10360 and forthcoming ISO 15530 standards. This series of standards focuses on geometrical product specifications, coordinate measuring machines, task specific measurement uncertainty, coordinate metrology, and performance assessment of coordinate measuring machines.

USE OF NEW CRYOGENIC CURRENT COMPARATOR BRIDGE IMPROVES RESISTANCE CALIBRATION SERVICE

NIST scientists recently built and installed a cryogenic current comparator for improving NIST's working resistance standards used in customer calibrations. The electrical resistance calibrations provided by NIST cover 17 orders of magnitude, from micro-ohm shunts to tera-ohm thin-film resistors. Maintaining the working standards requires that metrologists accurately transfer the value of the national ohm, established with the quantum Hall effect at 1 Ω to 10 kΩ, by using ratio measurements.

Previously the scaling measurements on which customer calibrations were based have been made with Hamon network devices which use banks of 10 or more wire-wound resistors. The assigned relative uncertainty of the Hamon process in the present uncertainty budget is 20×10^{-9}. Today's most accurate method of resistance ratio scaling is the cryogenic current comparator. This technique was first developed at NIST in the 1970s using superconducting quantum interference device (SQUID) technology and operates at the cryogenic temperature of liquid helium, or 4 K. In this technique, two different currents are exactly compared by containing the magnetic flux associated with both of the currents in a superconducting shield, and detecting any difference with the SQUID.

This new method of scaling from 1 Ω to 10 kΩ will provide significantly lower uncertainties in resistance calibrations. It reduces the scaling uncertainty by a factor of four so that this component of the relative uncertainty budget is now 5×10^{-9}. The result is that NIST can provide much better calibrations for more-demanding customer applications, including NIST's own determinations of fundamental constants.

ACTIVE AC VOLTAGE DIVIDER EXTENDS RANGE FOR PRIMARY ELECTRIC POWER CALIBRATIONS

A special-purpose ac voltage divider system has been developed by researchers at NIST to meet the demand for power and energy calibrations of extended range. The primary realization of the quantity of ac electric power, the watt, is achieved with a current-comparator-

based "power bridge" that has been optimized for 120 V, 5 A operation. Calibrations at lower voltages and currents are performed using scaling transformers within the bridge. To extend the upper voltage limit of the bridge, an active ac resistive voltage divider has been designed to scale input voltages of up to 600 V to the 120 V operating level of the bridge with less than 5 νV/V uncertainty in amplitude ratio. A novel two-stage design overcomes the limitations of finite gain of the operational amplifier of the simple active voltage divider circuit. In this way the errors of the single-stage divider that would normally be 1 mV/V are reduced to below 1 μV/V. A two-stage output circuit also was designed to allow use with two-stage voltage transformers while maintaining errors below 5 μV/V. The divider has four ranges for 50 Hz and 60 Hz operation: 240 V, 360 V, 480 V, and 600 V. It will be used at NIST to meet the demand for calibrations of wattmeters and watthour meters of U.S. electric utility and meter manufacturers.

NIST ADVANCES SPEECH RECOGNITION TECHNOLOGY

The use of automatically generated transcriptions of broadcast news for indexing and retrieving—the "spoken document retrieval" task—was the subject of a NIST paper presented at the Broadcast News Transcription and Understanding Workshop held in February, 1998. The preliminary test results indicated that the best performance was achieved using combinations of information retrieval and automatic speech recognition technologies.

NIST also reported the results of a benchmark test involving 10 research teams from research sites in the United States and Europe. The researchers were required to automatically generate transcriptions of a 3-hour test set synthesized by NIST, comprising over 150 news stories. NIST's role consisted of scoring the submissions, and computing and reporting on the word-error rate achieved by the different sites. The best performance was achieved by a group at Cambridge University's Engineering Department, with a word error rate of 16.4 %. Additional test results were reported for systems tasked with automatic transcription of broadcast news in Spanish and Mandarin. The latest in a series of annual meetings, the workshop focused on exploration of the use of recorded excerpts from broadcast news, and automatic speech recognition technology, in an information technology context. Approximately 200 researchers in speech recognition and information technology attended the meeting, which was sponsored by the Defense Advanced Research Projects Agency (DARPA).

NIST RESEARCHER COMPLETES WORK ON INFORMATION MODEL CRUCIAL TO INTERNATIONAL STANDARD

A NIST researcher recently completed his contribution to the development of the International Organization for Standardization's Exchange of Product model data (STEP), Application Protocol 210 (AP 210), "Electronic Assembly Interconnect and Packaging Design." The AP 210 standard is intended to meet a long-term industry goal, enabling the definition of computer-sensible descriptions necessary to describe designs of printed circuit assemblies or other electronic components. The researcher's 2-year effort in support of it is crucial to the success of AP 210 and thus to electronic commerce for the electronics industry.

Starting in 1996, the NIST researcher accepted sole responsibility for developing the 171-part geometric dimensioning and tolerancing (GD&T) portion of the of the AP 210 model. The importance of this portion stems from the increasing geometric complexity of electronic components and assemblies and the increasing use of automated inspection equipment. Automatic inspection tools need information on the tolerances of the component under inspection to determine whether it is manufactured within the levels defined by the product specifications. Lacking AP 210, GD&T requirements have been specified by a designer on a technical drawing. Manufacturing and inspection personnel then would manually enter this data into their automated manufacturing and inspection equipment. When AP 210 becomes available, this information will be handled in electronic form in accordance with the standard. Errors introduced by manual data re-entry will be eliminated, and significant reductions in manufacturing cycle time are anticipated when the GD&T information is supplied to manufacturing analysis tools. These reductions are expected to result because the analysis tools will be able to identify designs that are difficult (or impossible) to manufacture before an attempt is made to build products. The format specified in AP 210 has been used successfully as the design file exchange format in the DARPA-sponsored Team Integrated Electronic Response (TIGER) project to demonstrate the use of engineering analysis tools via the internet. The standard is currently in ISO's Draft International Standard (DIS) review process and expected to complete its DIS ballot by the end of 1998.

INDUSTRY AND GOVERNMENT BENEFIT FROM PUBLISHED SPECIFICATIONS FOR VALIDATION OF IMPLEMENTATIONS OF DATA ENCRYPTION STANDARD (DES) OR SKIPJACK ALGORITHMS

In February 1998, NIST issued Special Publication 800-17, Modes of Operation Validation System (MOVS): Requirements and Procedures. This document replaces, and expands on, SP 500-20, Validating the Correctness of Hardware Implementations of the NBS Data Encryption Standard (DES). Those seeking formal NIST validation of their implementation of the DES or Skipjack algorithm will utilize this special publication.

The MOVS specifies individual sets of validation tests, which must be completed successfully to validate an implementation of the DES or Skipjack algorithms. A separate set of validation tests has been developed for the encryption and decryption processes of each mode of operation.

The MOVS is composed of two types of validation tests: Known Answer tests and Modes tests. The Known Answer tests are used to verify that implementations correctly implement the components of the algorithm (e.g., S boxes, permutation tables, . . .). The Known Answer tests operate on the idea that given known input, a known output must be produced.

The second type of validation test, the Modes test, verifies that the implementation being tested has not been designed just to pass the Known Answer tests. A successful series of Modes tests also gives assurance that an anomalous combination of inputs would not result in an error.

MOVS testing is performed as part of the NIST Cryptographic Module Validation (CMV) Program. The CMV Program uses laboratories accredited by the NIST National Voluntary Laboratory Accreditation Program to test cryptographic products that conform to NIST standards. A vendor contracts with an accredited laboratory to perform the tests. After the testing is complete, the laboratory submits the results to NIST for validation. If the vendor's implementation of the specific algorithm has passed the tests successfully, NIST issues a validation certificate to the vendor.

OpenGL ADOPTS NIST FORTRAN 90 BINDING

The Fortran 90 bindings for the OpenGL graphics library developed by a NIST scientist have been approved by the OpenGL Architecture Review Board (ARB) as the official OpenGL Fortran 90 interface. The bindings also have been endorsed by X3J3, the U.S. Fortran Standards Committee.

OpenGL is a software interface for applications to generate interactive two-dimensional and three-dimensional computer graphics. OpenGL is designed to be independent of operating system, window system, and hardware operations and is supported by many vendors, with products for computing platforms from PCs to supercomputers. The ARB is the governing board of OpenGL and consists of members from a variety of companies with OpenGL products.

Adoption of the OpenGL Fortran 90 bindings represents a significant development for scientific visualization in the Fortran community. Until now there has never been an industry standard for generating graphics from Fortran programs; instead, only proprietary libraries that support a limited number of systems have been available. With the new bindings, a Fortran programmer can write standard-conforming graphics applications that will be portable over most computing platforms.

In conjunction with this work, the NIST scientist has developed f90gl, a public domain reference implementation of the Fortran 90 bindings (http://math.nist.gov/f90gl). Since its initial release over a year ago, it has been downloaded approximately 1200 times. With the standardization of the bindings, it is anticipated that the rate will increase and that vendors will use f90gl as the basis for their products. Several vendors already have expressed such interest.

NIST HOSTS CAM-I MEMBERS AT WORKSHOP FOCUSED ON ESTABLISHING COLLABORATIVE PROJECTS

In February 1998, NIST and the Consortium for Advanced Manufacturing International (CAM-I) conducted a joint technical workshop at NIST for the purpose of pursuing collaborative research focusing on infrastructural technologies and standards to support scalable flexible manufacturing systems. The 35 invited participants included representatives from industry and academia.

Industry members of the CAM-I Quality Assurance Program (QAP) provided a demonstration of a soon-to-be-released promotional video that explains how the Dimensional Inspection Technique Specification (DITS) can be used in industry to support dimensional inspections using coordinate measuring equipment. The CAM-I QAP DITS project is a research effort supporting the development of mathematically based sample point measurement techniques dependent upon different manufacturing process conditions, and part tolerances.

Workshop members heard presentations on several of NIST's technical projects in order to establish a framework for discussing collaborations with CAM-I industry and academic members. After some discussion, CAM-I identified five NIST projects that could be leveraged to support CAM-I's Scalable Flexible Manufacturing Program. CAM-I also encouraged strengthening NIST's involvement in the development of the DITS standard.

Proceedings of the workshop will be prepared by CAM-I and made available on the CAM-I web page, (www.cam-i.org) and the MEL web page (www.mel.nist.gov/melhome.html).

TOOL STABILITY INCREASED IN HIGH SPEED MILLING

Researchers from NIST working cooperatively with a major aircraft manufacturer, successfully demonstrated the concept of tool tuning in high-speed milling. Physically, regenerative chatter in machining results from the time-delayed feedback that occurs when a tool cuts over a surface that has been previously cut. This "regeneration" leads to vibrations that are the primary factor limiting material removal rates in machining. By understanding the complex dynamics of regenerative chatter, tools can be tuned so they are dynamically stable at a specified set of operating parameters. The work demonstrated that by increasing the length-to-diameter ratio of an 11.8 mm diameter carbide endmill from 9:1 to 10:1, the cutting stability at the top speed (20 000 rpm) of the high-speed machining center at the NIST shop facility actually can be increased.

NEW TECHNIQUES FOR MEASURING ELECTRON DENSITIES IN PLASMAS

NIST researchers are developing a new method for measuring spatially resolved electron densities in plasmas similar to those used in processing of semiconductor devices. Weak electron beams are injected into the plasma, and the frequency of the resulting plasma waves is proportional to the square root of the electron density. Controlling the size and direction of the electron beam gives a spatial map of the plasma electron density. The new technique can be used where traditional electron density probes (which measure dc current) are not possible, and the electron plasma waves are unaffected by rf plasma oscillations that hinder other techniques.

The plasma wave technique has been compared with Langmuir probe measurements in a wide variety of different plasmas in a special NIST inductively coupled plasma source. The source is a modified Gaseous Electronics Conference (GEC) Reference Cell vacuum chamber producing high density ($\approx 10^{11}$ cm^{-3}), low pressure ($\approx$1 Pa) plasmas similar to those found in commercial semiconductor etching and deposition reactors, but has a standardized geometry with numerous ports for plasma diagnostics. The plasma waves produced in this source typically have frequencies from 1 GHz to 10 GHz.

In the neutral plasmas being investigated, the electron densities measured by the Langmuir probe and plasma wave techniques rarely agree. This result is expected since the electron density measured by the probe is too low due to electron reflection and re-emission from the probe. The electron densities measured with the wave technique fall in between the Langmuir probe electron density and ion density results, where the actual value of the electron density is expected. This work will be reported in an upcoming issue of Plasma Source Science and Technology.

PHOTON CROSS SECTION DATABASE NOW AVAILABLE ON-LINE

NIST has developed a World Wide Web version of data describing the interaction of high energy photons with matter. The reference, XCOM: NIST X-Ray and Gamma-Ray Attenuation Coefficients and Cross Sections Database (Standard Reference Database 8), can be used to calculate photon cross-sections for scattering, photoelectric absorption, pair production, and total attenuation coefficients for any element, compound, or mixture, at photon energies from 1 keV to 100 GeV. Data on the scattering and absorption of photons (x rays, gamma rays, bremsstrahlung) are required for many scientific, engineering, and medical applications. Two NIST scientists originally developed this database for the radiological physics and dosimetry communities.

In the WWW version, both tabular and graphical information are provided. The database allows the user to customize the data presentation by specifying desired photon energies. Alternatively the user can accept a standard set of energies or a combination of standard and custom energies.

The Photon Cross Sections Database is available at http://physics.nist.gov/PhysRefData/Xcom/XCOM.html. A complete set of the databases currently provided by NIST is found at http://physics.nist.gov/ PhysRefData/ contents.html.

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NONLINEAR DYNAMICS OF INTENSE FEMTOSECOND PULSE PROPAGATION

Researchers at NIST are measuring and modeling the nonlinear dynamics of the propagation of intense femtosecond pulses in bulk media. This work arises from recent advances in femtosecond lasers, and improves understanding of laser design, atmospheric propagation of laser light, laser-plasma interactions, and optical switching.

Femtosecond pulse propagation in bulk media has many features not encountered in the more familiar problem of pulse propagation in optical fibers. In bulk media one must consider linear and nonlinear couplings between the spatial and temporal components of the laser field. In this regime, many aspects of femtosecond pulse propagation have been adequately explained by the standard (3+1)-dimensional nonlinear Schroedinger equation (NLSE), which accounts for diffraction, group velocity dispersion, and instantaneous Kerr nonlinearity. However, as intensities increase and pulsewidths decrease, the standard NLSE fails, and propagation details become unknown.

Knowing what additional physical mechanisms must be included in the model and verifying the subsequent predictions experimentally are both challenging tasks. Calculations are computationally expensive, and accurate measurements are difficult due to the complex spectral, spatial, and temporal variations in the electric field. On-axis measurements made with frequency-resolved optical gating allow the observation of the evolution of both the temporal amplitude and phase of femtosecond pulses as they undergo rapid broadening and splitting while propagating in fused silica. These accurate measurements have initiated the development of a more complete modified NLSE, which includes contributions of physical mechanisms such as Raman nonlinearities, space-time coupling, nonlinear shock effects, and nonparaxiality.

The improved model successfully predicts temporal asymmetries observed in the measurements. More recently, the technique of spectral interferometry has been applied to full beam measurements, permitting the measurement of the full (temporal plus spatial) electromagnetic field on a femtosecond time scale for the first time.

SP 250 SERIES FOR RADIOMETRIC MEASUREMENTS UPDATED

Three updated NIST Special Publications in the 250 series have recently been published by NIST. SP 250-41, Spectroradiometric Detector Measurements, describes detector responsivity measurements and calibrations in the ultraviolet, visible, and near-infrared spectral ranges. SP 250-43, Radiance Temperature Measurement Calibrations, describes radiance temperature standards for disappearing filament optical pyrometers, ribbon filament lamps, and radiation thermometers. SP 250-48, Spectral Reflectance Measurement Services, includes description of the instrumentation, standards, and techniques used to measure spectral reflectance over the ultraviolet, visible, and near infrared wavelengths.

NIST's SP 250 series provides detailed descriptions of important features of specific calibration services. These documents provide a description of the (1) specifications for the services; (2) design philosophy and theory; (3) measurement system; (4) operational procedures; (5) assessment of the measurement uncertainty, including random and systematic effects and an uncertainty budget; and (6) internal quality control procedures used by NIST. These documents present more detail than can be provided in calibration reports or generally allowed in articles in scientific journals. SP 250s make detailed measurement information easily available to users of NIST measurement services and provide a basis for comparing quality of measurements among different laboratories.

SODIUM BOSE-EINSTEIN CONDENSATION PRODUCED

Researchers recently verified the production of NIST's first sodium Bose-Einstein condensate (BEC), bringing NIST's share to three of the 10 BECs generated worldwide. In an appropriate twist of fate, NIST scientists first produced the new BEC in the early morning hours following Group Leader William Phillips' public NIST colloquium on Jan. 24 describing the group's Nobel Prize-winning research on laser cooling. Gaseous BEC is a unique state of matter where atoms cool sufficiently that they all condense into a single quantum state, in effect forming a huge molecule with extraordinary properties.

To obtain the BEC, researchers laser cooled sodium atoms to the 100 μK temperature range and loaded the cooled atoms into a so-called time-orbiting potential (TOP) magnetic trap. The TOP trap has both static quadruple and rotating magnetic field components, which can be adjusted to change the sodium atom density and permit evaporation of the warmer atoms from the trap. The remaining colder atoms condense into the BEC at temperatures near 1 μK. Group members continue to optimize the condensation conditions and now routinely achieve BECs containing about 106 sodium atoms.

Most BECs—including the world's first produced at NIST/JILA in 1995—are made from rubidium, which can be laser cooled using near infrared light from diode lasers. Sodium condensation is considerably more challenging, requiring stronger magnetic fields for confinement and compression of the atoms, and laser cooling with 589 nm radiation (the familiar yellow-orange glow of sodium vapor lamps) generated by complicated and touchy dye laser systems.

Mastery of sodium BEC production has allowed the group to begin experiments using the condensate. Researchers have used standing light waves to Bragg diffract atoms out of the condensate, forming a directed, coherent atom beam, a forerunner of a practical "atom laser." They also have demonstrated an atom interferometer, in which laser light is used to split up the condensed atom cloud and then recombine the parts, resulting in constructive and destructive interference of the atoms depending on phase difference between the two paths, analogous to interference of light scattered off a diffraction grating.

DEVELOPMENT OF STANDARD TEST METHOD TO ASSESS GRINDING DAMAGE IN CERAMIC MATERIALS INITIATED

Based on work carried out by the 22-member NIST Ceramics Machining Consortium, ASTM Committee C28 on Advanced Ceramics recently accepted a proposal to develop a new standard to assess the effect of grinding damage on flexural strength of ceramics. A task group has been established to carry out the effort. Grinding is the predominant method used to shape and finish ceramic parts to achieve the high precision and close tolerances required for most mechanical components. Grinding damage can take several forms—the most serious being near-surface microcracks. The presence of grinding induced microcracks can seriously reduce flexure strength, by as much as 30 % for relatively tough silicon nitrides, for example, and even more for less tough materials. The ASTM standard under development will compare the flexural strength of specimens prepared in a way to be unaffected by surface damage with that of specimens subjected to process-grinding conditions.

NEW SYSTEM FOR NANOSCALE MULTILAYER DEPOSITION ALLOWS CONTROL OF THICKNESS AND LAYER SEQUENCE

A new high-vacuum thin film deposition system designed and built by NIST scientists is being used to fabricate thin-film multilayer coatings. These coatings are of interest because of their reported special thermal, mechanical, and electronic properties. The deposition system has three electron beam sources capable of evaporating a wide variety of metals, semiconductors, and ceramics. The evaporated materials condense on substrates to form thin-film coatings. Computer-controlled shutters over the electron beam sources are opened or closed according to feedback from thickness monitors. This flexibility permits the user to define layer sequences and thicknesses. The deposition system already has been used to deposit a variety of single layer and multilayer films with layer thicknesses from nanometers to micrometers.

To gain an understanding of some of the special properties reported for multilayer systems, the crystallography of titanium in multilayer structures has been evaluated. Other researchers, using transmission electron microscopy (TEM), have concluded that titanium in multilayers deposits with a face centered cubic crystal structure, otherwise unknown in titanium. However, x-ray diffraction studies of as-deposited films produced in the new deposition system have shown that for titanium layered with silver, aluminum, nickel, or copper, the titanium deposits with its equilibrium hexagonal lattice structure for all of the layer thicknesses studied. The titanium was found to transform to the face centered cubic structure during TEM sample preparation. These results illustrate the importance of careful structural measurements on multilayers when interpreting properties.

ENERGY-RELATED INVENTIONS PROGRAM MAKES RECOMMENDATIONS

The NIST Office of Technology Innovation recently prepared technical evaluation reports on five commercially promising innovative technologies in response to NIST's current statutory mission under the Energy-Related Inventions Program (ERIP).

Low-Speed Variable-reluctance Generator Systems—a simple and low-cost generator and solid-state controller particularly suited for variable speed service, for example in windmill applications. The technology of variable reluctance generators also is applicable to motors.

Soil Moisture Sensor and Control System—a sensor designed to measure the moisture content of the soil and to allow automatic control of irrigation devices in adding water to the soil on an as-needed basis.

Method for Casting Hurricane Structure Anchors in Concrete (AnCore System)—an innovative design for casting anchors in concrete. The anchors provide a structural connection between wall framing, trusses, girders, and the concrete.

A Device for Tank Gauging and Level Control in Locomotives and LNG-Fueled Trucks (Noverflo Liquid Level Gauge (NLLG))—a device for liquid measurement in the fuel tanks of railroad locomotives with possible application to LNG-fueled trucks.

Treatment of Polluted Water Using Wetland Plants in a Floating Habitat—a process for bioremediation of polluted waste waters using the natural biodegradation capability of wetland plants.

As of Aug. 1, 1997, DOE's Office of Industrial Technologies (OIT) restructured ERIP and renamed the initiative the "Inventions and Innovation Program (IIP)." At this time, NIST/OTI stopped accepting submissions of innovative technology for evaluation under ERIP. The restructured program will be administered for DOE/OIT from DOE's Golden, CO, field office as a yearly competitive solicitation. NIST no longer will provide technology evaluation or co-sponsor the program. The 1998 solicitation was issued on May 1 and will close on July 31, 1998.

NIST HOSTS RADAR CROSS SECTION MEASUREMENT CERTIFICATION MEETING

NIST and the Air Force Research Laboratory jointly sponsored the second annual Radar Cross Section (RCS) Certification Meeting in Boulder, CO, March 1998. Approximately 60 attendees from government, industry, and academia convened to discuss issues of common concern related to maintaining and improving the quality of measurements throughout the RCS community. A major focal point was a Department of Defense (DoD) pilot project to develop, test, and implement a voluntary national RCS Measurement Certification Program. NIST was the organizer and host.

Topics of discussion included methods for the proper and cost-effective characterization of measurement systems, the reporting and evaluation of measurement uncertainties, and current results of laboratory intercomparison projects involving standard targets and polarimetric calibrations. The three government laboratories (at Wright-Patterson, Patuxent River, and Holloman) which are candidates for certification in the DoD pilot project reported on the status of their preparations. A private company also announced its intention to work for certification during this project. A standard guide, Handbook for the Assurance of Radar Cross Section Measurements, based on ISO/IEC Guide 25, General requirements for the competence of calibration and testing laboratories, is being developed and reviewed by the participants of the meeting. To gain broad support in the standards community, and also to garner valuable feedback, greater involvement in National Conference of Standards Laboratories activities is planned. Additionally, because of its importance of uncertainty evaluation, a workshop on uncertainty analysis will be held at the Ohio State University this summer.

NIST WORKS WITH INDUSTRY TO APPLY USABILITY TESTING RESULTS IN THE PROCUREMENT OF SOFTWARE

In March 1998, NIST hosted the Workshop on Applying Usability Testing Results as Procurement Criteria for Software. Industry participants included usability experts from private industry.

The objectives of the workshop were to specify a minimal usability testing process and a standardized reporting procedure for usability results that software vendors would supply to corporate customers who could factor that information into their purchasing decisions. A third goal of the workshop was to develop a pilot project to determine the effect of such a testing process and reporting standard.

Workshop participants had many concerns both from the consumer and vendor side. However, they all felt that this was a step in the right direction but that the process and reporting form must be crafted carefully. Participants formed three working groups. Group 1 will investigate management issues associated with this process and will draft a white paper, which will accompany the process and report form; Group 2 will draft the process and metrics section; and Group 3 will produce a pilot plan for evaluating the effect.

NIST will host a follow-up workshop in September 1998 to discuss the outputs of the working groups and to finalize the draft. The draft will be made publicly available in October 1998 on a web site hosted by NIST. After receiving public comments and incorporating them as appropriate into the document, the pilot plan will be implemented in January 1999. NIST intends to hold periodic workshops to evaluate the pilot plan and to revise the draft as needed.

NIST AND PRIVATE COMPANY CO-SPONSOR NORTH AMERICAN ISDN USERS' FORUM (NIUF)

NIST and a private company co-sponsored the 32nd meeting of the NIUF in February 1998. Approximately 100 users, implementors, and service providers for Integrated Services Digital Network (ISDN) technology attended the NIUF, which was held in Napa, CA.

Working group sessions were held and three documents were approved by the NIUF: Update to NIUF 422-97– Voice Terminal Simplification Procedures; NIUF 445-98– Data Dictionary; and NIUF 446-98–

"ISDN Anywhere" Guidelines. Four documents were announced as working group stable and are expected to be approved at the June 1998 NIUF: ISDN Ordering Codes for Always On/Dynamic ISDN; Definition of Feature Set 11; Naming Convention for the NIUF Capability Packages; and Archiving Capability Packages E, G, N, and T. The Simplification of ISDN Ordering, Provisioning and Installation chair will send a letter to CPE suppliers and service providers regarding their support of the Voice Terminal Simplification Procedures (NIUF 442-97).

A prior work effort, Multimedia Applications and Networking, has been rejuvenated. An ad hoc group may also form regarding "Focus on Applications." This issue will be discussed in the interim and brought to the next NIUF, scheduled for June 1998 at NIST.

WORKSHOP ON STANDARDS FOR NUCLEIC ACID DIAGNOSTIC APPLICATIONS

NIST has hosted the first forum for all of the communities involved in molecular diagnostic testing. The workshop, entitled "Standards for Nucleic Acid Diagnostic Applications," was held in March 1998. This interdisciplinary dialogue focused on the types of standards needed by laboratories so the public can be assured that laboratory results are accurate. Also addressed were the needs for proper quality assurance methods and materials so testing laboratories may be positioned to provide the best possible results.

Nucleic acid-based diagnostics have revolutionized testing and human identification in forensics, medical molecular genetics, infectious diseases, and cancer. With nucleic acids as a central theme for a growing number of diagnostic tests, there is a need for consensus standards for the many tests performed by laboratories in the private and public sectors. The workshop focused on three areas: molecular genetics, cancer diagnostics, and infectious diseases. Major issues facing the nucleic acid diagnostic community were discussed, and a series of recommendations concerning the management of these issues were developed following productive breakout sessions.

Topics discussed during the meeting included (1) the role of nucleic acid diagnostics in medical management, (2) novel technologies, (3) the nature of nucleic acid standards in various technologies, (4) automation in nucleic acid analysis, and (5) current technologies and problems in the accurate measurement of repeated DNA that occurs with a variety of genetic diseases.

The meeting was sponsored by NIST as well as the Association of Government Toxicologists, the Centers for Disease Control, the Food and Drug Administration, the National Committee for Clinical Laboratory Standards, and the Health Care Financing Administration. Approximately 100 scientists representing commercial and Federal laboratories as well as teaching and research hospitals were in attendance.

NIST HOSTS ISO AND OIML MEETINGS ON WATER METER STANDARDS

With the worldwide rise in costs associated with producing and delivering potable water, accurate measurement of delivered volume is becoming increasingly important. Global sales of water meters are around the $3 billion per year level. To assist in addressing this issue, NIST recently hosted two international working group meetings, with the aim of harmonizing water meter standards and to facilitate trade.

Working Group 7 of ISO/TC30/SC7 met in February 1998, to discuss a new draft of ISO 4064-1, Measurement of water flow in closed conduits—Meters for cold potable water—Part 1: Specifications, that will incorporate an improved classification system that separates design and performance specifications for water meters.

Working Group 2 of the OIML/TC8/SC5 also met at NIST in February 1998 to discuss a draft revision of OIML R49 Water Meters Intended for the Metering of Cold Potable Water, that concentrates on the regulatory aspects of water meters and is intended to be in harmony with the new ISO 4064-1. A follow-up meeting is scheduled for June 1998 in The Hague, the Netherlands.

STANDARDS INFORMATION SEMINAR HOSTED AT NIST

NIST hosted a seminar on standards information for representatives from 17 Latin American countries in March 1998. The seminar, part of the Standards in Trade Workshop program, provided an opportunity for participants to gain a greater understanding of their responsibilities as national inquiry points, required under the World Trade Organization Agreement on Technical Barriers to Trade (TBT Agreement); to learn how to implement or improve national standards information centers; and to acquire skills for indexing and cataloguing standards documents effectively. Seminar topics included obligations under the TBT Agreement related to information and assistance, operation of national standards information centers, standards-related information products and services, management of a standards document collection, and use of computer databases and the Internet to collect and disseminate information.

The seminar program was based on ISO Development Manual 8, Organization and Development of a National Standards Information Centre.

The countries represented at the seminar were Argentina, Bolivia, Brazil, Chile, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela. A representative of the Central American Research Group for Industry, ACAITI, also attended.

INTERNATIONAL COLLABORATION ON DATA EXCHANGE STANDARDS FOR THE PROCESS INDUSTRIES

NIST played a pivotal role in establishing PIEBASE (Process Industry Executive for achieving Business Advantage using Standards for data Exchange), a worldwide forum to harmonize and coordinate industry programs to develop, demonstrate, and standardize needed data exchange and data sharing standards. The PIEBASE members are industry consortia around the globe active in the development of international standards for the process and process plant industries, including: PISTEP (United Kingdom), PlantSTEP (United States), Plant CALS (Japan), POSC (International), POSC/CAESAR (Europe), and USPI-NL (Netherlands).

NIST organized the first PIEBASE industry session for a recent international conference held in Houston, "Plant Design and Plant Management Automation Strategies." More than 800 attendees listened to presentations on the emerging ISO data exchange standards, current implementations of the standards, and the strategies of industry leaders to use these standards for improving their business capabilities and their profits. The session informed the process, power, engineering, and construction industries about the suite of STEP (a.k.a., ISO 10303) application protocols (APs) under development to meet their business needs. The first of these new ISO standards to be approved as a Draft International Standard is STEP AP 227, Plant Spatial Configuration, developed by PlantSTEP, Inc., a U.S. industry consortium, and NIST. The session concluded with a panel discussion on mechanisms for accelerating use of these standards by U.S. industry and on the industry priorities for additional data exchange and data warehousing standards.

Standard Reference Materials

SRM AVAILABLE FOR OPTICAL FIBER METROLOGY

Optical fiber communication systems are becoming more complex as operators try to push ever more information down the same fibers. In particular, wavelength references are needed in the 1500 nm region to support current and future wavelength division multiplexed (WDM) optical fiber communication systems. In a WDM system, many wavelength channels are sent down the same fiber, thereby increasing the bandwidth of the system by the number of channels. If one channel's wavelength were to shift, cross-talk could occur between it and a neighboring channel. Wavelength references are needed to calibrate optical instruments used to evaluate system components and measure the channels' wavelengths.

NIST's solution is to produce Standard Reference Materials with optical fiber coupled cells containing gases which have accurately measured absorption lines in the 1500 nm region. NIST ruled out establishing a calibration service because the instruments needed are large, fragile and could be offset during shipment. The first SRM, number 2517, is based on the fundamental absorptions of light by acetylene; another SRM based on hydrogen cyanide is being developed.

To obtain more information on SRM 2517, contact Sarah Gilbert, MS 815.03, NIST, Boulder, CO 80303-3328, (303) 497-3120, sgilbert@boulder.nist.gov. To order the acetylene absorption line standard, contact the SRM Program, Building 202, Rm. 204, NIST, Gaithersburg, MD 20899-0001, (301) 975-6776, fax: (301) 948-3730, srminfo@nist.gov.

NIST PRODUCES FIRST STANDARD REFERENCE MATERIAL FOR THE FLUID POWER INDUSTRY

Scientists at NIST have worked closely with the National Fluid Power Association to develop the first Standard Reference Material (SRM 2806) and two associated Reference Materials (RM 8631 and RM 8632) for use in calibrating particle contamination monitoring devices. Particulate contamination of lubricants in hydraulic systems is a serious and costly problem that is common

to mobile equipment, ships, planes, large vehicles, and machines for manufacturing. Optical particle counters are widely used by the fluid power industry to monitor the particle contamination levels of fluids and to test the capacities and characteristics of filters used in hydraulic systems.

The National Fluid Power Association (NFPA), an organization that promotes technical interests and standards for the fluid power industry, asked NIST to develop a Standard Reference Material that provides national and international traceability for contamination measurements. SRM 2806 consists of ISO Medium Test Dust (a silica mineral dust), suspended at a known concentration in clean MIL-H-5606 hydraulic fluid. The material is certified for the total number of particles greater than a series of specified particle sizes per milliliter of fluid. After quantitative particle filtration, scientists used automated scanning electron microscopy (SEM) and digital image processing to size more than 775 000 particles from 4400 SEM image fields. SRM 2806 will be replacing a test material that has been accepted and used internationally by the industry for over 25 years, and in doing so will advance the measurement accuracy and precision for contamination monitoring applications and liquid particle filter testing.

SRM 2806 is critically important on national and international levels because the material is required to perform calibrations or accepted measurement protocols for NFPA and ISO. Other standard measurement protocols such as Multipass Filter Tests and Solid Contamination Level Codes are also based on SRM 2806. Additionally, SRM 2806 impacts several international standards that are "documents central to hydraulic contamination control programs worldwide . . ." says the chairman of ISO/TC 131/SC 6.

The RMs are also critical components of the NFPA and ISO standard methods. RM 8631 consists of the same mineral dry dust used in SRM 2806. It allows users to produce transfer standards for calibrating particle counters from a sensor calibrated using SRM 2806. RM 8632 is composed of an ISO ultra fine dry test dust and is used to verify the performance of optical particle counters.

The development of these materials in collaboration with the fluid power industry is an example of government and industry working together to improve U.S. leadership, competitiveness, and influence through national and international standards.

Volume 103, Number 2, March–April 1998
Journal of Research of the National Institute of Standards and Technology

Calendar

May 29, 1998

BALTIMORE-WASHINGTON CHAPTER OF THE HEALTH PHYSICS SOCIETY

Location: National Institute of Standards and Technology
Gaithersburg, MD

Sponsors: NIST and the Baltimore-Washington Chapter of the Health Physics Society
Audience: Baltimore-Washington area radiation safety professionals.
Format: Presentation.
Purpose: To present radiation protection practices.
Topics: Radiation safety.
Technical Contact: Janna Shupe, NIST, Building 245, Rm. C125, Gaithersburg, MD 20899-0001, phone: 301/975-5800, fax: 301/977-2283, email: janna.shupe@nist.gov.
Electronic Registration: https://www.niwt.gov/conf/secure/CONF24/conf_register.htm

July 20–21, 1998

INTERNATIONAL WORKSHOP ON OPTICAL FERROELECTRIC MATERIALS

Location: Hilton Resort
Breckenridge, CO

Sponsor: NIST.
Audience: Optical ferroelectric materials community.
Format: Lecture.
Purpose: This bi-annual workshop is aimed at the science and technology of optical ferroelectric materials, emphasizing areas such as optical telecommunications, and remote sensing.
Topics: Optical ferroelectric materials and advances.
Technical Contact: Norman Sanford, NIST, Mailcode 815, 325 Broadway, Boulder, CO 80303-3328, phone: 303/497-5239, email: sanford@boulder.nist.gov.

August 9–12, 1998

1998 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS RADIO AND WIRELESS CONFERENCE

Location: Sheraton Hotel
Colorado Springs, CO

Sponsors: NIST, Institute of Electrical and Electronics Engineers (IEEE), and Institute for Telecommunication Sciences (ITS).
Audience: Engineers in commercial wireless communication.
Format: Single-track, technical sessions, workshops, panel sessions, and exhibitions.
Purpose: To provide an interactive forum for new results in wireless communications and advance the process of industry standardization.
Topics: Systems, active components, passive components, measurements, antennas, and propagation.
Technical Contact: Michael S. Heutmaker, Lucent Technologies, P.O. Box 900, Rm. 2-2063, Princeton, NJ 08542-0900, phone: 609/639-3116, fax: 609/639-3197, email: heutmaker@lucent.com.
Conference WWW Homepage: http://rawcon.org/

August 20–22, 1998

FIRST ADVANCED ENCRYPTION STANDARD (AES) CANDIDATE CONFERENCE

Location: DoubleTree Inn
Ventura, CA

Sponsor: NIST.
Audience: International audience consisting of cryptographers and other interested parties who wish to participate in the evaluation and analysis of candidate algorithms for the Advanced Encryption Standard (AES).
Format: Presentations, demonstrations, and discussions.

Purpose: A process to develop a Federal Information Processing Standard (FIPS) for Advanced Encryption Standard (AES) specifying an Advanced Encryption Algorithm (AEA) has been initiated by NIST. NIST is currently soliciting candidate algorithms for inclusion in the AES. The purpose of this conference is to announce and present the AES candidate algorithms to the public, in order to begin and facilitate the Round 1 Evaluation and Analysis Period.
Topics: FIPS, AES, AES Analysis Packages, and AEA.
Technical Contact: Miles Smid, Building 820, Rm. 412, Gaithersburg, MD 20899-0001, phone: 301/975-2938, fax: 301/948-1233, email: miles.smid@nist.gov.
Jim Fot, NIST, Building 820, Rm. 417, Gaithersburg, MD 20899-0001, phone: 301/975-5237, fax: 301/948-1‘233, email: james.foti@nist.gov.
General Information: Ed Roback, NIST, Building 820, Rm. 426, Gaithersburg, MD 20899-0001, Phone: 301/975-3696, fax: 301/948-1233, email: edward.roback@nist.gov
Conference WWW Homepage: http://csrc.mist.gov/encryption/aes/aes_home.htm
Electronic Registration: https://www.nist.gov/conf/secure/CONF9/conf_register.htm

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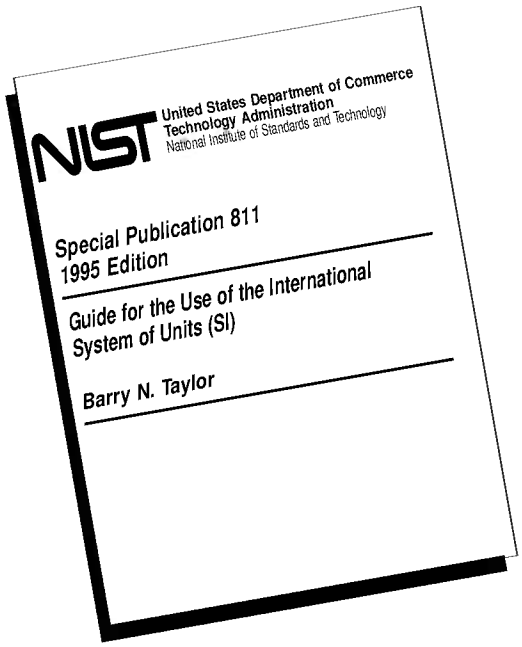
The International System of Units (SI)
The Modern Metric System



Uncertain about the International System of Units (universally abbreviated SI), the modern metric system used throughout the world? Do you need to know the proper way to express the results of measurements and the values of quantities in units of the SI? Do you need to know the NIST policy on the use of the SI? Then you need the 1995 edition of the National Institute of Standards and Technology Special Publication 811, *Guide for the Use of the International System of Units (SI)*.

The 1995 edition of the National Institute of Standards and Technology Special Publication 811, *Guide for the Use of the International System of Units (SI)*, by Barry N. Taylor, is now available.

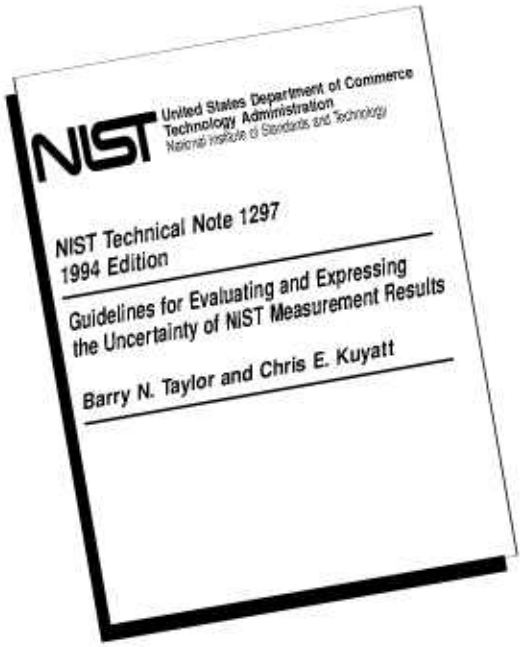
The 1995 edition of SP 811 corrects a number of misprints in the 1991 edition, incorporates a significant amount of additional material intended to answer frequently asked questions concerning the SI and SI usage, and updates the bibliography. The added material includes a check list for reviewing the consistency of written documents with the SI. Some changes in format have also been made in an attempt to improve the ease of use of SP 811.

The topics covered by SP 811 include:

- NIST policy on the use of the SI in NIST publications.
- Classes of SI units, those SI derived units that have special names and symbols, and the SI prefixes that are used to form decimal multiples and submultiples of SI units.
- Those units outside the SI that may be used with the SI and those that may not.
- Rules and style conventions for printing and using quantity symbols, unit symbols, and prefix symbols, and for spelling unit names.
- Rules and style conventions for expressing the results of measurements and the values of quantities.
- Definitions of the SI base units.
- Conversion factors for converting values of quantities expressed in units that are mainly unacceptable for use with the SI to values expressed mainly in units of the SI.
- Rounding numbers and rounding converted numerical values of quantities.

Single copies of the 84-page SP 811 may be obtained from the NIST Calibration Program, Building 820, Room 232, Gaithersburg, MD 20899-0001, telephone: 301-975-2002, fax: 301-948-3825.

Evaluating and Expressing the Uncertainty of Measurement Results



Uncertain about expressing measurement uncertainty? Do you need to know how NIST states the uncertainty of its measurement results and how you can implement their internationally accepted method in your own laboratory? Then you need the newly available 1994 edition of the National Institute of Standards and Technology Technical Note 1297, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results.*

The 1994 edition of the National Institute of Standards and Technology Technical Note 1297, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, by Barry N. Taylor and Chris E. Kuyatt is now available.

The 1994 edition of TN 1297 includes a new appendix—Appendix D—which clarifies and gives additional guidance on a number of topics related to measurement uncertainty, including the use of certain terms such as accuracy and precision. Very minor word changes have also been made in a few portions of the text of the 1993 edition in order to recognize the official publication in October 1993 by the International Organization for Standardization (ISO) of the *Guide to the Expression of Uncertainty in Measurement* on which TN 1297 is based. However, the NIST policy on measurement uncertainty, Statements of Uncertainty Associated with Measurement Results, which is reproduced as Appendix C of TN 1297, is unchanged.

It is expected that the 1994 edition of TN 1297 will be even more useful than its immediate predecessor, the 1993 edition, of which 10 000 copies were distributed worldwide.

Those United States readers who wish to delve into the subject of measurement uncertainty in greater depth may purchase a copy of the 100-page ISO *Guide* from the Sales Department of the American National Standards Institute (ANSI), 105-111 South State Street, Hackensack, NJ 07601. Copies may also be purchased from the ISO Central Secretariat, 1 rue de Varembé, Case postale 56, CH-1211 Genève 20, Switzerland.

Single copies of the 20-page TN 1297 may be obtained from the NIST Calibration Program, Building 820, Room 232, Gaithersburg, MD 20899-0001, telephone: 301-975-2002, fax: 301-948-3825.

NIST Technical Publications

Periodical

Journal of Research of the National Institute of Standards and Technology—Reports NIST research and development in those disciplines of the physical and engineering sciences in which the Institute is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology and the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Institute's technical and scientific programs. Issued six times a year.

Nonperiodicals

Monographs—Major contributions to the technical literature on various subjects related to the Institute's scientific and technical activities.

Handbooks—Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications—Include proceedings of conferences sponsored by NIST, NIST annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

National Standard Reference Data Series—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NIST under the authority of the National Standard Data Act (Public Law 90-396). NOTE: The Journal of Physical and Chemical Reference Data (JPCRD) is published bimonthly for NIST by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements are available from ACS, 1155 Sixteenth St., NW, Washington, DC 20056.

Building Science Series—Disseminates technical information developed at the Institute on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

Technical Notes—Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NIST under the sponsorship of other government agencies.

Voluntary Product Standards—Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The standards establish nationally recognized requirements for products, and provide all concerned interests with a basis for common understanding of the characteristics of the products. NIST administers this program in support of the efforts of private-sector standardizing organizations.

Order the **following** *NIST publications—FIPS and NISTIRs—from the National Technical Information Service, Springfield, VA 22161.*

Federal Information Processing Standards Publications (FIPS PUB)—Publications in this series collectively constitute the Federal Information Processing Standards Register. The Register serves as the official source of information in the Federal Government regarding standards issued by NIST pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

NIST Interagency Reports (NISTIR)—A special series of interim or final reports on work performed by NIST for outside sponsors (both government and nongovernment). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service, Springfield, VA 22161, in paper copy or microfiche form.

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